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A COMPARISON OF THE OLIGOCENE OF WESTERN EUROPE AND THE SOUTHERN UNITED STATES

BY

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THE OLIGOCENE OF THE SOUTHERN UNITED STATES

INTRODUCTION

The validity of the correlation of certain beds of the southern United States with the European Oligocene, although generally assumed, may be regarded as open to question. The writer has, therefore, attempted a comparison of these deposits with the typical Oligocene beds of western Europe, as a contribution to the evidence on this subject.

To gain a general knowledge of the European Oligocene molluscan forms, studies were made at the Paris, Bordeaux and Brussels museums of paleontology. The geographical distribution of the species in the basins of Paris, Rennes, Mainz, the Gironde, the Adour, Belgium and northern Germany was also carefully noted.

During the spring and summer of 1900, field work was carried on in the French and Belgian Oligocene basins. The commoner and many of the characteristic species were collected from these beds. A nearly complete set of stratigraphic specimens was also obtained to illustrate the mineralogical characters of the horizons.

When possible, photographs were taken, but as the country is very level and of no great elevation in the Oligocene sections of France and Belgium, the camera could be used advantageously only in open quarries.

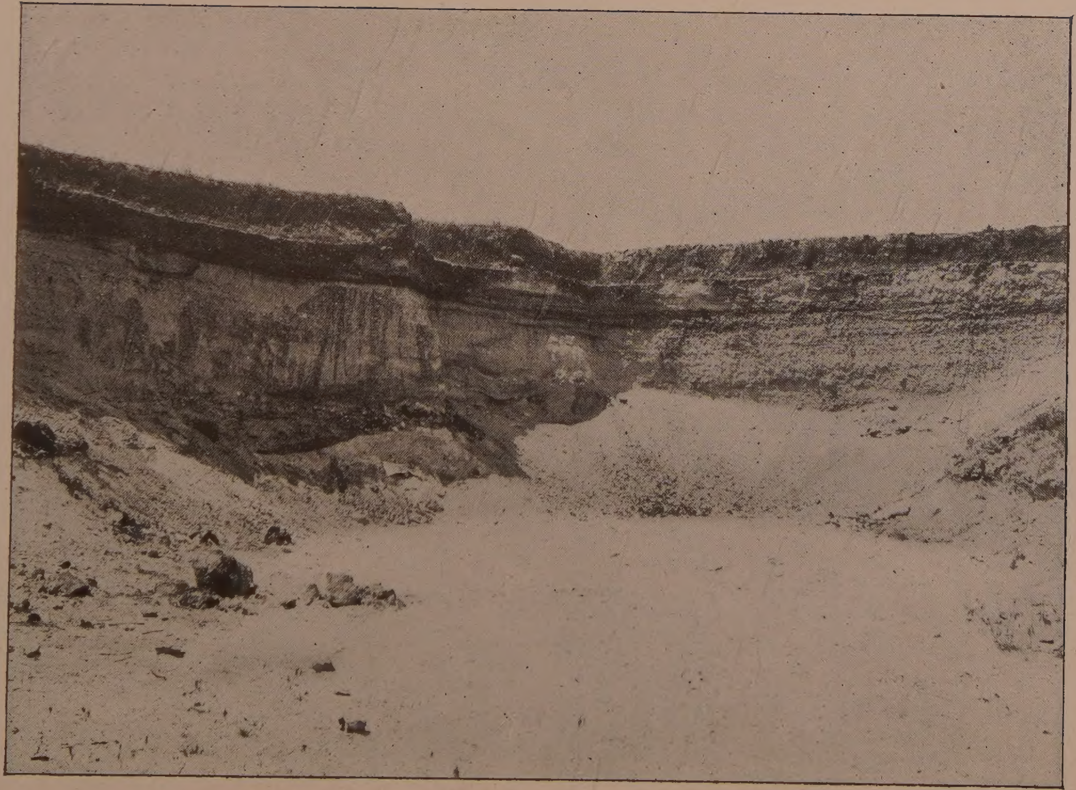
For purposes of comparison a brief review of the Oligocene of western Europe is given. A bibliography of species was also prepared. This list, while not absolutely complete or free from synonymes ,comprises several thousand species and is intended to serve as a practical University laboratory guide to the fauna.

Under the direction of Professor G. D. Harris, collections have been made, during several successive years, for Cornell University, of the Tertiary fauna of the southern United States.

The Oligocene material thus obtained has been studied and identified by the writer, kindly aided in cases of doubt by Dr. W. H. Dall and Mr. Vaughan of the Smithsonian Institution. Many new species in the collection can at present be classed only generically since similar specimens are in the Smithsonian collection awaiting description by Dr. Dall. A few new species not in the latter collection are described.

A number of sections and field notes made in 1900–1902 by Professor Harris in northern Florida, in Georgia, Alabama and Mississippi, illustrating Chattahoochee and Orbitoides limestones and Grand Gulf sandstones, have been placed by him at the writer's disposal.

The writer wishes to thank Professor Harris of Cornell, Professor Stanislas–Meunier and Monsieur G. Ramond of the Jardin des Plantes, Professor Fallot of the University of Bordeaux, Professor Van den Broeck and Professor Rutot, Curators of the Royal Museum at Brussels, for many courtesies and much practical help.



THE QUARRY AT JEURRE (see page 9).

PART I.

THE OLIGOCENE OF WESTERN EUROPE

Field Work in the Oligocene of France and Belgium.

The European fossiliferous deposits have been visited by collectors for so many years that in many localities the supply of fossils is greatly diminished, or even exhausted, as in the basin of the Adour. The level topography and consequence absence of natural sections make the collector dependent on artificial exposures such as are obtained in quarries and sand pits, or along roadside cuts. Of these quarries, some once famous for their fossiliferous beds have been long abandoned. That of Jeurre, where Deshayes and Lamarck obtained many Oligocene types, is filling up with material washed down from above. A photograph of this quarry as it now appears is shown on opposite page. The once equally noted sand pit of Morigny is to-day quite hidden in a thicket, and the fossiliferous sands are overgrown with grass and rendered almost inaccessible by the interlacing roots of trees.

In Belgium an obstacle was encountered which was practically insurmountable. The Government claimed a monopoly[*] of the building sands of the country and consequently ordered that many of the sand pits hitherto worked by private companies should be filled up. This resulted in the closure of many of the fossiliferous deposits, as, among others, that of Berg.

Nevertheless, the lithological characters of the principal beds were studied and samples of the deposits were collected. The writer was also fortunate enough to secure the following species:

+*Conovulus pyramidalis*, T. Sow.,[†]	Antwerp.
Limnæa strigosa,	Romainsville.
‘‘ *ventricosa*,	Montmorency.
Planorbis cornu,	Romainsville.

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[*] To avoid the taxation resulting from this monopoly, the peasants steal the sands by night. In many places holes, lightly covered with sod, are evidences of these depredations.

[†] A number of Pliocene species, which are indicated by a (+), are included in the list.

	Tornatella simulata Sol.,	Boom.
+	*Cylichna cylindracea* Penn.,	Antwerp.
	Bulla (*Haminea*) *turgidula* Desh.,	Morigny.
+	*Terebra inversa* Nyst,	Antwerp.
	Conus aquitanicus Mayer,	La Saubotte.
+	*Pleurotoma antverpiensis* Delh.,	Antwerp.
	“ *belgica* Munster,	Morigny.
	“ “ “	Jeurre.
+	“ *costata* Da Costa,	Antwerp.
	“ *denticula* Bast.,	Steendorp.
	“ *Duchasteli* Nyst,	“
	“ *intorta* Brocchi,	“
	“ *Konincki* Nyst,	“
	“ *regularis* Van B.,	“
	“ *Selysii* De Kon.,	Grimmertingen.
	“ “ “	Steendorp.
	“ *turbida* Sol.,	“
	Cancellaria evulsa Sol.,	Boom.
	Oliva Basterotina Defrance,	La Salle.
	“ *Defresnei* Basterot,	La Saubotte.
	“ *subclavatula* d’Orb,	Le Thil.
+	*Voluta Lamberti* T. Sow.,	Antwerp.
	“ *Rathieri*,	Grimmertingen.
	“ *suturalis* Nyst,	“
	Fusus Deshayesi De Kon.,	Steendorp.
	“ *elatior* Beyr,	“
	“ *elongatus* Nyst,	“
+	“ *gracilis* Da Costa,	Antwerp.
	“ *multisulcatus* Nyst,	Steendorp.
	“ *Waelii* Nyst,	“
+	*Chrysodomus contraria* Sow.,	Antwerp.
	Buccinum baccatum Bast., var.,	Lariey.
	“ (*Pseudostrombus*) *Gossardi* Nyst,	Pierrefitte.
	“ “ “	Morigny.
	“ “ “	Jeurre.
	“ “ “	Grimmertingen.

+	*Buccinum undatum* L.,	Antwerp.
	Nassa Aquitanica Mayer,	La Saubotte.
+	“ *consociata* Sow.,	Antwerp.
+	“ *labiosa* T. Sow.,	“
+	“ *lamellilabra* Nyst,	“
+	“ *propinqua* Sow.,	“
+	“ *reticosa* T. Sow.,	“
+	*Buccinopsis Dalei* T. Sow.,	“
	Columbella curta (?),	La Saubotte.
	Typhis (*Lyrotyphis*) *cuniculosus* Desh.,	Morigny.
	“ “ “ “	Grimmertingen.
	Murex Deshayesi Nyst,	Steendorp.
	“ cf. *Lasseignei* Bast.,	Lariey.
	“ *Pauwelsii* De Kon.,	Steendorp.
	“ cf. *scabriusculus* Grat.,	Lariey.
	“ *variabilis* Grat.,	“
+	*Acanthina tetragona* Sow.,	Antwerp.
	Triton Flandricum De Kon.,	Steendorp.
	“ “	Grimmertingen.
+	*Cassidaria bicatenata* Sow.,	Antwerp.
	“ *nodosa* Brand.,	Steendorp.
+	*Chenopus pes-pelicani* L.,	Antwerp.
	“ *speciosus* Schloth,	Boom.
	Cerithium Boblayei Desh.,	Brunehaut.
	“ *calculosum* Bast.,	La Garde.
	“ (*Potamides*) *conjunctum* Desh.,	Morigny.
	“ *corrugatum* Bast.,	Le Son.
	“ *elegans* Desh.,	Vieux-Joncs.
	“ *fallax* Grat.,	La Saubotte.
	“ *margaritaceum* Brocchi,	Lariey.
	“ *papaveraceum* Bast.,	La Salle.
	“ (*Pirenella*) *plicatum* Lmk.,	Morigny.
	“ “ “ “	Le Son.
	“ “ “ “	Lariey.
	“ *pupæforme* Bast.,	La Saubotte (?)
	“ *sub-margaritaceum* Braun,	“ “
+	“ *tricinctum* Brocchi,	Antwerp.

Cerithium (*Potamides*) *trochleare* Lmk.,	Morigny.
Bittium spina Partsch,	Villeandraut.
Potamides Lamarcki Brongn.,	Franconville.
“ “ “	St. Martin.
“ “ “	Ormoy.
Turritella Desmaresti Bast.,	La Saubotte.
+ “ *incrassata* T. Sow.,	Antwerp.
“ *vasatensis* Tourn., (in coll.),	La Saubotte.
Bayania (*Melania*) *semidecussata* Lmk.	Étrechy.
“ “ “ “	Pierrefitte.
+*Littorina suboperta* Sow.,	Antwerp.
+*Rissoa vitrea* Mont.,	“
Bithinia Dubuissoni Bouillet,	St. Martin.
Cyclostoma antiquum Brongn.,	“ “
+*Pileopsis ungarica* L.,	Antwerp.
Calyptræa (*Galerus*) *labellata* Desh.,	Morigny.
“ “ “	Jeurre.
“ (*Luna*) *striatella* Nyst,	Morigny.
“ *sinensis* Desh.,	Lariey.
+ “ “	Antwerp.
Xenophora Deshayesi,	Le Son.
Natica achatensis Recluz,	Steendorp.
“ *Delbosi* Heb.,	Gaas, (Landes).
“ *Hantoniensis* Pilk.,	Grimmertingen.
“ (*Naticina*) *micromphalus?*, Sandb.,	Pierrefitte.
“ “ “ “	Morigny.
+ “ *millepunctata* Lmk.,	Antwerp.
“ *neglecta* Mayer,	Lariey.
+*Adeorbis subcarinatus* Montagu,	Antwerp.
+*Eulima subula* Donov.,	“
Neritina Ferussaci (*Nerita picta*),	La Salle (La Brède).
+*Emarginula crassa* T. Sow.,	Antwerp.
Dentalium Kickxi Nyst,	Morigny.
“ “ “	Steendorp.
Ostrea cyathula Lmk.,	Argenteuil.
“ “ “	Villejuif.
+ “ *edulis* L.,	Antwerp.

	Ostrea longirostris Lmk.,	St. Aubin.
	" *producta* Delbos,	Lariey.
	" *queteleti* Nyst,	Brouk.
	" *undata* Lmk.,	Sainte-Croix-du-Mort.
	" *ventilabrum* Goldf.,	Brouk.
+	*Anomia sphippium* L.,	Antwerp.
	Pecten bellicostatus Wood,	Brouk.
	" "	Grimmertingen.
+	" *Gerardi* Nyst,	Antwerp.
	" *Hoeninghausi* Defr.,	Klein-Spauwen.
	" " "	Steendorp.
+	" *maximus* L.,	Antwerp.
+	" *opercularis* L.,	"
+	*Pinna pectinata* L.,	"
	Mytilus Aquitanicus Mayer,	Lariey.
	Arca cardiiformis Bast.,	La Saubotte.
	" " "	Lariey.
	" *turonica* Dujardin,	Villeandraut.
	Pectunculus (*Axinea*) *angusticostatus* Lmk.,	Jeurre.
	" " " "	Morigny.
	" *cor* Bast.,	Château du Thil.
+	" *glycimeris* L.,	Antwerp.
	" *obvatus*,	Klein-Spauwen.
	" "	Jeurre.
	" "	Morigny.
	" "	Pierrefitte.
	Nucula Greppini Desh.,	Morigny.
	" " "	Jeurre.
+	" *lævigata* Sow.,	Antwerp.
	Leda Deshayesiana Desh.,	Steendorp.
	" " "	Boom.
	" " "	Tamise.
	" *gracilis* Desh.,	Jeurre.
	Cardita (*Actinobolus*) *Bazini* Desh.,	Pierrefitte.
	" *hippopea* Bast.,	Lariey.

	Cardita Kickxi Nyst & West,	Boom.
	“ “ “ “	Tamise.
	“ “ “ “	Steendorp.
	“ *Omaliana* Nyst,	Klein-Spauwen.
+	“ *orbicularis* Leach,	Antwerp.
+	“ *scalaris* Leath,	“
	“ *Tournoueri* Mayer,	Villeandraut.
+	*Astarte Basteroti* L.,	Antwerp.
+	“ *corbuloides* Nyst,	“
	“ *Henckeliusiana* Sow.,	Klein-Spauwen.
+	“ *incerta* S. Wood,	Antwerp.
	“ *Kickxi* Nyst,	Tamise.
	“ “ “	Boom.
+	“ *Omaliusi* L.,	Antwerp.
	Cardium cingulatum (?) Goldf.,	Grimmertingen.
+	“ *decorticum* S. Wood,	Antwerp.
+	“ *edule* L.,	“
	“ (*Cerastoderma*) *Raulini* Heb.,	Jeurre.
	“ “ “ “	Morigny.
	“ “ “ “	Pierrefitte.
	“ *Stampinensis* Stan-Meun.,	“
	“ (*Plagiocardium*) *tenuisulcatum* Nyst,	Morigny.
	“ “ “ “	Jeurre.
	“ “ “ “	Pierrefitte.
	Cyprina Islandica L.,	?
	“ *rotundata* Braun,	Steendorp.
+	“ *rustica* T. Sow.,	Antwerp.
	Isocardia cor L.,	“
+	*Cytherea chione* L.,	“
	“ (*Pitar*) *incrassata* Desh.,	Morigny.
	“ “ “ “	Jeurre.
	“ (*Callista*) *splendida* Mer.,	Grimmertingen.
	“ “ “ “	Pierrefitte.
	“ “ “ “	Morigny.
	“ “ “ “	Jeurre.
	“ *undata* Bast.,	Lariey.
	“ “ “	La Garde.

Cytherea variabilis Stan-Meun.,	Pierrefitte.
Circe Deshayesi,	Lariey.
“ “	Le Son.
“ cf. *Banoni*,	Lariey.
+*Dosinia exoleta* L.,	Antwerp.
+*Venus casina* L.,	“
“ *ovata* Penn. (1777),	Lariey.
Diplodonta Bezançoni Stan-Meun.,	Pierrefitte.
Axinus unicarinatus Nyst,	Boom.
Ensis siliqua L.,	Antwerp.
Cyrena convexa,	Near Paris.
“ *semistriata* Desh.,	Klein-Spauwen.
+*Mactra arcuata* T. Sow.,	Antwerp.
Lutraria sanna Bast.,	Le Son.
“ “ “	Lariey.
+*Mya truncata* L.,	Antwerp.
Corbula carinata Duj.,	Lariey.
“ *Henckeliusana* Nyst,	Jeurre.
“ “ “	Morigny.
“ *pisum* (?) Nyst,	Klein-Spauwen.
“ *striata* Walk. & Boys.,	Boom.
+*Corbulomya complanata* Sow.,	Antwerp.
“ *Morleti* Stan-Meun.,	Pierrefitte.
“ *triangula* Nyst,	“
+*Panopæa angusta* Nyst,	Antwerp.
+ “ *Faujasii* M. de la G.,	“
Lucina dentata Bast.,	Lariey.
“ *incrassata* Dub. de Montp.,	“
“ (*Dentilucina*) *Heberti* Desh.,	Morigny.
“ “ “ “	Pierrefitte.
“ “ “ “	Jeurre.
“ *ornata* Agassiz,	Lariey.
“ (*Jagonia*) *squamosa* Lmk.,	Morigny.
“ “ “ “	Jeurre.
“ *undata* Lmk.,	“
Tellina Benedeni Nyst & West,	“
“ (*Peronæa*) *Nysti*, Desh.,	“
+ “ *obliqua* Sow.,	Antwerp.
+*Gastrana laminosa* T. Sow.,	“
+*Syndosmya prismatica*,	“

A REVIEW OF THE OLIGOCENE OF WESTERN EUROPE.

The Oligocene in Germany. The Oligocene of northern Germany is chiefly marine, while that of the valleys of the Oder, the Elbe and the Rhine is of freshwater or brackish origin.

The lignitic formation. The freshwater beds, which are gulf deposits, are composed of conglomerates, siliceous sands, sandstones, clays and shales; but lignitic remains of cypress and other coniferous woods predominate. At Cassel these lignitic beds are referable to the middle Oligocene (Rupelian). Similar deposits in the Rhenish provinces, however, probably represent the upper Oligocene (Aquitanian of Mayer). In 1864 Giebel[*] described the fauna of the lignitic formation.

Marine beds. Marine deposits representing the lower Oligocene (Tongrian) lie to the north of Berlin, and to the southwest of Magdeburg. The middle and upper Oligocene (Rupelian and Anquitanian) marine beds are, however, of greater importance and cover a large part of the northern plains of the country.

Geological map. A geological map of Germany, which has long been needed, is in preparation. Of this a portion was published in 1894 by Richard Lepsius,[†] but the complete map is presumably still unfinished.

Beyrich's classification of the marine beds. Beyrich, in 1853, made the following classification[‡] of the Tertiary formation of northern Germany:

3. Beds equivalent to the Bordeaux formations........Miocene ?
2. Septaria clays...................... } Fauna intermediate between
1. Magdeburg sands................. } Eocene and Miocene.

In his description of these beds Prof. Beyrich notes the strikingly intermediate character of the fauna of the Magdeburg sands and the Septaria clays. Nevertheless, he refers them both to the lower Miocene.

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[*] Die Fauna der Braunkohl. form. Latdorf, 1864.

[†] Geologischer Karte des Deutschen Reichs.

[‡] Die Conchylien der Norddeutschen Tertiärgebirges. *Zeitschrift der Deutschen geol. Gesellschaft*, 1853, 1855, 1856. Also published sep. vol. 8°.

Name Oligocene proposed, 1854. Continuing his researches, he found these faunal differences so constant that the following year, he referred the beds to an independent period. This he named the Oligocene,* and considered it as coordinate with the Eocene and Miocene periods.

Magdeburg sands. The Magdeburg sands, which represent the lower Oligocene beds in Germany, are characterized by *Ostrea ventilabrum*, *Arca appendiculata*, *Pleurotoma Beyrichi* and *P. subconoidea*. The sands are most fossiliferous near Neustadt-Magdeburg, Osterweddingen and Westerregln. The lower Oligocene fauna of these and other localities has been studied especially by Philippi,† Beyrich,‡ Speyer,‖ and von Koenen.§

Septaria clays. The Septaria clays of Hanover and Mecklenburg, which correspond to the Septaria clays of Boom and Mainz, and represent middle Oligocene deposits, sometimes attain a depth of 160 metres. Foraminifera are very characteristic in these clays. The commonest molluscan species are *Leda Deshayesi*,

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* *Monatsbericht der Berliner Akademie der Wissenschaften* von Nov. 1854.

† Beiträger zur Kenntniss d. Tertiärversteinerungen d. Nordwestlichen Deutschlands. Cassel in 4°, 85 pp. 4 pl., 1843; Verzeichniss der in d. Gegend von Magdeburg aufgefundenen Tertiärversteinerungen. *Paleontographica* I, pp. 42–90, pl. 7, fig. 10a, 1847.

‡ Die Conchylien der Norddeutschen Tertiärgebirges, Berlin, in-8°, 30 pl. Also published in *Zeits. d. Deutsch. geol. Gesellschaft*, V, VI, VIII, 1853, 55, 56.

‖ Ueber einige Tertiär-Conchylien von Westeregeln im Magdeburgischen. *Paleontographica*, IX, *zweiter Lieferung*, pp. 80–85.

§ Die Fauna d. Unter-Oligocænen Tertiärschickten v. Helmstädt bei Braunschweig. Berlin, in-12°, 75 pp., 2 pl. (*Extrait du Journ. de la Soc. géol. allemande, année* 1865, p. 459, pl. 15 et 16); Beiträger zur Kenntniss der Mollusken-Fauna d. Norddeutschen Tertiärgebirge. *Paleontographica* part XVI, p. 145, pl. 12 to 14, 1866; Ueber die Unter-Oligocæne Tertiärfauna von Aralsee. Marburg, in-8°, 31 pp., 1869. (*Bull. de la Soc. imp. des Naturalistes de Moscou.* n. 1.)

See also Böttger, Osc., Beitrag zur päläontologischen u. geologischen Kenntniss d. Tertiärformation in Hessen. Offenbach, 1869.

Fusus multisulcatus, *F. elongatus*, *Pleurotoma intorta*, *P. Konincki* and *Borsonia gracilis*. Full discussions of the fauna are gived by von Koenen[*] and Speyer.[†]

Sands of Stettin. A somewhat later deposit than the Septaria clays are the sands of Stettin which usually overlie the clays and cover a wide area of the northern plains. The sands are characterized by *Pectunculus Philippi*, *Cardium cingulatum* and *Cyprina rotundata.*

Sands of Cassel and Bunde. At Bunde and Cassel are marine sands of upper Oligocene age, corresponding, as Beyrich anticipated in 1853, to the Bordeaux (Aquitanian) beds. The characteristic fossils[‡] are *Echinolampus Kleini*, *Pecten Janus*, *P. Munsteri* and *Terebratula grandis.*

In 1827, Goldfuss published the first scientific treatise[‖] on the fossils of Germany. This was based on a study of private collections, especially that of Comte G. de Munster. A number of Oligocene species of various horizons are described in the work.

The Oligocene in Belgium. In Belgium, middle and lower Oligocene beds occur in the eastern part of the country in the province of Limbourg, and in central Belgium in the province of Brabant. The upper Oligocene is but little represented, and, as regards marine horizons, is wholly lacking.

Dumont's classification. Alexandre Dumont[§] made the first classification of the Belgian Oligocene.

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[*] Das marine Mittel-Oligocæn Nord-Deutchlands u. seine Molluskenfauna, 1867, Cassel, 148 pp. (Extr. *Paleontographica*, *Band* XVI, pl. VI, VII, XXVI to XXX.

[†] Die Tertiärfauna v. Sollingen bei Jerxheim im Herzogthum Braunschweig. *Paleontographica* IX, 1864, 7 *Lief.*, p. 247.

[‡] See Speyer, Die Conchylien der Casseler Tertiär-Bildungen. *Paleontographica*, Band XVI, 5 Lief., pp. 175-218 (1866-1869); also Bd. IX (1862-1864); Die oberoligocænen Tertiärgebilde u. deren Fauna in Fürstenthum Lippe-Detmold, in-4, 52 pp., 5 pl., *Paleontographica*, part XVI.

[‖] Petrefacta Germaniæ, Dusseldorf, 1827; second edition by Giebel, 1866.

[§] Mémoire sur la constitution géologique de la province de Liège, in 4°. (Inseré dans les Mém. couronnés de l'Acad. roy. de Bruxelles).

Bolderian system.
Upper Rupelian system.
Lower " "
Upper Tongrian "
Lower " "

Tongrian. The name Tongrian was derived from the ancient Flemish town of Tongres,* not far from Liège in eastern Belgium, where typical lower Oligocene beds occur.

Rupelian. The name Rupelian was derived from the river Rupel, a tributary of the Escaut, since typical middle Oligocene exposures are found along the valley, as at Boom.

The Bolderian a Miocene horizon. Dana† refers the Bolderian to the upper Oligocene, which it was thought to be by Belgian geologists until 1884. In that year M. Van den Broeck‡ showed that the Bolderian contains a typical Miocene fauna and should be properly placed in the lower Miocene. He attributes the error customarily made in regard to its geological position to the fact that, in some localities, Oligocene fossils have been washed into the Bolderian beds.

The classification of the Oligocene proposed by M. Van den Broeck|| in 1894, was adopted by the Belgian government in 1896.

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* The town itself is named from the Tongri who originally dwelt in the neighborhood. This tribe, under the leadership of the brave Ambiorix, resisted the Roman army with such determined courage that Cæsar himself was compelled to come from England to support his generals, and only by a war of extermination were the Tongri subdued. The Romans were obliged, by the continuance of this warfare, to remain several years in camp at Tongres. During this time an extensive wall and fortifications were built, the ruins of which are now the delight of archeologists. Pliny, who accompanied the army as historian, devoted himself to a study of the geology of the region. He described, in particular, a remarkable carbonated spring. This is generally identified with a large spriug near the town called the Fountain of Pliny.

† Manual of Geology, 1894, p. 926.

‡ Note sur la découverte des fossiles miocènes dans les dépôts de l'étage bolderien à Wænrode. *Ann. Soc. R. Malac. Belgique*, t. 19, 1884. See also by the same author, Rapport sur une excursion faite le 16 juillet 1874 au Bolderberg, près de Heosselt, *Ann. de la Soc. Malacologique de Belgique*, IX, 1874.

|| Coup-d'oeil Synthétic sur l Oligocène Belge. Bruxelles, 1894.

Classification adopted in 1896.

OLIGOCENE OF HIGH BELGIUM.

	UPPER HORIZON.
Fluvio-lacustrine.	Plastic clays, variously colored, containing an Aquitanian flora.
	Sands and gravels. Cross-bedded stratification.
	Sandstone of Coudroy.
	Conglomerate of the Ardennes.
	Layers of white quartz pebbles.
	LOWER HORIZON.
Marine (littoral).	Fine sands with traces of annelids. Meuse Valley.

OLIGOCENE OF MIDDLE AND LOW BELGIUM.

	Rupelian (*Middle Oligocene*).
	UPPER HORIZON.
Marine.	White sands, becoming argillaceous.
	Clay of Boom. *Leda Deshayesiana.*
	Sands.
	Coarse sands and gravel.
	LOWER HORIZON.
Marine.	White sands.
	Clays. *Nucula compta.*
	Sands of Berg. *Pectunculus obovatus.*
	Green clays, alternating with sands.
	Flint gravel beds.
	Tongrian (*Lower Oligocene*).
	UPPER HORIZON.
Brackish.	Marls of Vieux-Joncs. *Cerithium elegans.*
	Green clays of Hénis. *Cytherea incrassata.*
	Sands of Bautersem. *Cyrena semistriata.*
	LOWER HORIZON.*
Marine.	Green clays.
	Micaceous sands of Neerepen.
	Argillaceous sands. *Ostrea ventilabrum.*
	Sands.
	Plastic clays.
	Gravel beds.

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* The lower Tongrien is referred by Lapparent to the Eocene.

Fossiliferous beds of Limbourg. The fossiliferous beds of Limbourg, being the standard to which all lower Oligocene deposits are referable, have an important place in geological literature. In addition to the work of Dumont, already mentioned, the publications of Nyst,* Hébert,† Bosquet,‡ Rutot,|| Mourlon§ and Van den Broeck** are important.

Ostrea ventilabrum beds. The *Ostrea ventilabrum* beds are best exposed in a sunken road which leads from Tongres to Brouk. Near that hamlet the steep sides of the road are formed of lower Tongrian sandy marls. These are concealed by sod and later formations except where a small open cave has been formed by undermining. The roof of this is full of *Ostrea* shells, especially the species *ventilabrum*, but *queteleti* is also fairly abundant. *Pecten bellicostatus* and *Cardium elegans* are common. A number of other species were also observed by the writer, but all excepting the *Ostrea* shells are so exceedingly fragile that they fall to pieces even on exposure to the air. To preserve the specimens it is necessary to soak them at once in gum arabic and allow them to dry thoroughly before attempting to transport them.

M. Vincent, director of the paleontological division of the Belgian survey, has identified some 42 species of mollusca from these beds. Among others he finds

Pinna margaritacea Lam. *Arca appendiculata* J. Sow.

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* Récherches sur les coquilles fossiles de Hoesselt et Kleyn-Spauwen, province de Limbourg, 1836, *Extrait du Messager des arts et des sciences de Gand.*

† Sur les foss. tert. du Limbourg, etc., *Bull. Soc. Géol. de Fr.*, 2 *sér.*, t. VI, 1849, p. 466.

‡ Récherches paléontologiques sur le terrain tertiaire du Limbourg neerlandais. Amsterdam, in-4°, 28 pp., 2 pl., 1859. (*Acad. des sci. naturelles d'Amsterdam*, D. VIII).

|| Déscription de la fauna de l'oligocène inférieur de Belgique (tongrien de Dumont), Bruxelles, in-8°, 1876, 4 pl. (1re partie seule pub.). (*Ann. de la Soc. malacologique de Belgique*, t. XI, pp. 1-67).

§ Géologie de la Belgique. 2 vol., in-8°, t. I, 1880, t. II, 1882. Liste générale de fossiles.

** Coupe d'oeil Synthétique jetté sur l'Oligocène Belge, 1894; and Rutot, Observations stratigraphiques relatives aux terrains oligocènes et quaternaires du Limbourg. *Ann. de la Soc. géol. de Belgique*, V, 1878, pp. 141-155.

Modiola Nysti Kickx.
“ *Sandbergeri* Bosq.
Pleurotoma acuticosta Nyst.
“ *Selysii* De Kon.
Pectunculus pulvinatus Lam.
Fusus elongatus Nyst.
Cancellaria evulsa Sol.
Natica labellata Lam.

Sands of Neerrepen and Grimmertingen. Although the sands of Neerrepen are exposed in a number of places, the only locality where fossils could be well obtained has been enclosed for more than 40 years in a private park in which collecting is forbidden. The sands are characterized by traces of annelids and valves of *Ostrea ventilabrum*. The deposit is littoral. Cross-bedding is frequent. The fauna is much the same as that of Grimmertingen, a hamlet 7 kilometers north of Tongres. At the base of the sands of Grimmertingen *Rostellaria*, *Ostrea*, *Pecten*, *Arca*, *Cardita*, *Pectunculus*, *Cardium*, etc., have been found; and in the upper layers, *Serpula*, *Murex*, *Fusus*, *Buccinum*, *Turritella*, *Natica*, etc. The utmost patience and care were neccessary in obtaining these specimens which were very fragile. For many years the supply of fossils at Grimmertingen has been exhausted, but all the species collected there and at Neerrepen are on exhibition at the Royal Museum in Brussels.

The lower Tongrian ends with the green clays, but this limit is for convenience only, and is not based on any marked break in the series.

Sands of Bautersem. The sands of Bautersem are usually very fine, snow-white or light green in color, and not micaceous. They contain no traces of annelids. *Cerithium*, *Cyrena* and *Limnæa* occur near the base.

Of the 32 species found in these sands the commoner are *Cyrena semistriata*, *Cerithium Lamarcki*, *Ostrea ventilabrum*, *Pectunculus lunulatus*, *Lucina Heberti*, *Astarte trigonella* Nyst, *Lucina Omaliusi* Desh., *Cytherea incrassata* J. Sow., *Psammobia stampinensis* Desh. and fruits of *Chara* associated with *Limnæa longiscata*.

The characteristic species are
Cerithium intradentatum Desh.
Limnæa longiscata Brongn.
Planorbis acuticarinatus Dunk.
Melania muricata E. Wood.

Bithinia tenuiplicata G. Vin.
" *inflata* Braun.
Bithinia hellicella Braun.
Cardium scobinula Mer.

The clays of Hénis. The clays of Hénis, so named because of the large brick and tile factories near that town, vary from pure plastic green clays, of great economic importance in tile making, to brownish black, sandy beds. The purer clays are found towards the upper part of the deposit. These are quite unfossiliferous and hence most valuable, because the presence of a single fossil is ruinous to a tile, since the lime becomes calcined in baking and leads to the disintegration of the tile. The sandy clays occurring towards the base of the formation often contain fossils, many of which are washed in from other beds, but *Cytherea incrassata* is sometimes found in place. While the clays of Hénis have no really characteristic species, some forms, rare in the underlying sands of Bautersem, become very common in the clays. Among these are *Neritina Duchasteli* Desh., *Modiola Faujasi* Brongn. and *Corbula pisum* Sow. Other species abundant in the clays are

Buccinum Gossardi Nyst.
Cerithium trochleare Lam.
" *cancellinum* G. Vin.
Cardium Kochi Semper.
Natica Nysti d'Orb.
Odostomia Semperi Bosq.
Turbonilla lævissima Bosq.
Cyrena neglecta Nyst.
Bithinia Duchasteli Nyst.

The sands of Vieux-Joncs. The sands and marls of Vieux-Joncs (Oude Biesen) are very fossiliferous, and the shells are best preserved in the park of the Château. Unfortunately, the writer found the park closed in the absence of the owner, but the same beds were observed further along the road. In this locality the marl was formed almost entirely of organic remains of which *Cerithium elegans* formed a large proportion. *C. Lamarcki* and *C. plicatum* were also observed in considerable numbers. The fauna of the Vieux-Joncs region is rich, but not varied, and comprises only about 50 species.

The characteristic species are

Buccinum Thierensi Bosq.
Teinostoma decussatum Sandb.
Cerithium limula Desh.
Bulla minima Sandb.

Odostomia Nysti Bosq.
“ *acutiusculum* Braun.
Lucina Thierensis Héb.
Rissoa turbinata Defr.
Mytilus subfragilis d'Orb.
Dreissensia Brardi Brongn.

Other species common in the sands are

Buccinum Gossardi Nyst.
Cerithium elegans Desh.
“ *plicatum* Brug.
“ *Lamarcki* Brongn.
Pleurotoma costellaria Duch.
Natica Nysti d'Orb.
Neritina Duchasteli Desh.
Pectunculus lunulatus Nyst.

Fossiliferous Rupelian beds. Paleontologically, the most important beds of the middle Oligocene (Rupelian) are the sand of Berg and the clays of Boom. Of the species in these deposits some were described by Jean Kickx* in 1830. De Koninck† and Nyst‡ later published important monographs. Comparatively recently M. Vincent of the Belgian survey has published a list‖ of the Rupelian fauna of Belgium.

The sands of Berg. As already noted, the writer found the sand pit at Berg, from which some seventy finely preserved species have been obtained, closed by order of the government. Another outcrop was then visited where *Pecten Hoeninghausi* was found to be very common, but still more abundant were the valves of *Pectunculus obovatus* which, by their number, distinguish these sands which lack markedly characteristic species. Among other mollusca reported as common in this deposit are

Voluta rathieri Héb.
Typhis cuniculosus Duch.
Triton Flandricum De Kon.
Cassidaria nodosa Sol.
Murex Deshayesi Nyst.
Fusus multisulcatus Nyst.

Nucula clays. The sands of Berg are followed by clays which are best developed in Limbourg and are characterized by *Nucula compta*. Otherwise the fauna is poor. The clays are somewhat arenaceous and the fossils poorly preserved. One rarely finds a perfect *Nucula*, but the clay is filled with nacreous fragments of the shells.

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* Synopsis Molluscorum Brabantiae, in-4°, 1 pl., 1830.

† Déscription des coquilles fossiles de Bæsele, Boom, Schelle, etc., in-4°, 1837; also in tome XI Mémoire de l'Académie royale des sciences et belles lettres de Bruxelles, 1838.

‡ Note a propos des coquilles fossiles de Boom. *Bull. de la Soc. Géol. de Fr.*, 1re sér., t. XIV, p. 451, 1843; Déscription des coquilles et des polypiers des terrains tertiaires de Belgique. In-4°, 1845; also in *Mém. couronnés de l'Acad. royale de Bruxelles*, t. XVII, 697 pp., 15 pl.

‖ Nouvelle liste de la faune conchyliologique de l'argile rupelienne. *Ann. Soc. R. Malac. de Belg.*, t. XXIII, 1888, pp. 38-40.

The clays of Boom. The clays of Boom, which are developed in the valley of the Rupel, are of great importance economically in the manufacture of bricks and tiles. At Steendorp, Tamise and especially at Boom, are large quarries, the working of which constitutes an important industry. The excavations have been carried on at Boom so as to form a regular series of terraces. Hence the quarry is strikingly like a vast coliseum. On the terraces great numbers of concretions (Septaria) are found, some beautifully iridescent with iron pyrites. As has been noted in the preceding pages, similar concretions are extremely common in the corresponding beds in northern Germany. The characteristic fossil of these clays is *Leda Deshayesiana*, which can readily be collected at any of the quarries.

M. Delheid of Brussels has made an admirable collection of fossils (which the writer was fortunate enough to see) from these clays. The species of corals and of crustaceans were very striking. Among the molluscan species, which amount to about sixty, *Ficula concinna* Beyrich, *Xenophora scrutaria* Phil., *Cancellaria evulsa* Sol., *Dentalium Kickxi* Nyst, *Perna Sandbergeri* Desh. and *Cassis Rondeleti* Bast., are comparitively common.

The Oligocene of the Paris basin. The Oligocene of the Paris basin forms a broad sheet lying chiefly between the Marne and Loire rivers. It extends east to Epernay, west to Chârtres, south to Orléans and Blois, and north to Paris. It is surrounded by Eocene except on the south and southeast where Miocene and Cretaceous beds occur. In the Eocene which forms the northern boundary, isolated outcrops of Oligocene can be observed at Montmorency, Ecouen and other localities.

The literature on the geology of the Paris basin is so voluminous that reference can be made here only to those publications in which many original descriptions of species are to be found.

Of these the most important are the works of Lamarck,* Deshayes† and d'Orbigny.‡

Section of the Paris basin Oligocene. The Oligocene of the Paris basin comprises the following strata:

Beauce Limestones.	2. Limestone of the Beauce and Montmorency millstones.
	1. Clays. *Potamides Lamarcki.* Alternating marine and freshwater beds.
Fontainebleau sands.	8. Sands of Ormoy.
	7. Sands and gravels of Saclas.
	6. Sands and shell-marls of Pierrefitte.
	5. Sands of Vauroux.
	4. Sands and gravels of Étrechy.
	3. Sands of Morigny.
	2. Sands of Jeurre.
	1. Oyster-shell marls and friable sandstones of Étrechy.
Brie limestone.	1. Brie limestones.
Green clays.	2. Green clays. Strontium concretions.
	1. Foliaceous clays. *Cyrena convexa*, *Cerithium*.

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* Mémoires sur les fossiles des environs de Paris. (*Ann. du Muséum de Paris*, 1802-1810); Histoire naturelle des animaux sans vertèbres, 1815, 2ème éd., 1835.

† Déscription des coquilles fossiles des environs de Paris, 2 vols., 1854; Déscription des animaux sans vertèbres découverts dans le basin de Paris, pour servir de supplément à la déscription des coquilles fossiles des environs de Paris, Paris, 3 vols., 1856.

‡ Prodrome de paléontologie stratigraphique, 2 vols., 1850.

See also Guettard, Mémoires sur le mineralogie des environs de Paris et sur les corps marins qui s'y trouvent *Histoire de l'Académie royale des sciences de Paris*, 1756.

Bruguière, Histoire naturelles des vers, 1792.

Cuvier et Brongniart, Essai sur la géographie minéralogique des environs de Paris, 1re éd., 1810, 2ème, 1822, 3ème, 1835.

Brongniart, Déscription géologique des environs de Paris, 1823.

Defrance, Tableau des corps organisés fossiles, Strasburg et Paris, 1824.

Bezançon, Déscription d'espèces nouvelles du bassin de Paris, *Journ. de Conchy.*, 3ème sér., 1870, pp. 310-323, Pl. X.

Bayan, Études critiques sur la collection de l'École des Mines, 1870-75.

	10. White clays. *Limnæa strigosa.*
	9. Blue clays.
Clays above the gypsum.	8. Gypsum (1st bed). Vertebrate fauna. *Palæotherium.*
	7. Yellow clays.
	6. Gypsum (2nd bed). Only Eocene species.
	5. Marls. *Lucina inornata.*
	4. Gypsum (3rd bed). A few Oligocene species.
	3. Yellow clays. *Pholadomya ludensis.*
Gypsum.	2. Gypsum (4th bed). Fauna resembling Eocene.
	1. Green sands of Argenteuil.

Base of the Oligocene series. The basal beds of the Oligocene in the Paris basin are not definitely determined. This is due to the lack of unconformity, the scarcity of well preserved fossils in the gypsum beds and the contradictory evidence given by the species which occur. Thus the fourth bed contains species closely resembling those from the Eocene (sables moyens). The third bed has mostly Eocene species, but contains also a few new, Oligocene types. The second bed is nearly unfossiliferous, but what species there are, are Eocene. The first bed is characterized by vertebrate remains, especially those of *Palæotherium.* Lapparent considers that the Oligocene series begins with the blue clays which rest on the first gypsum bed. Cossman and Lambert include the gypsum in the Oligocene. Others claim that the green clays characterized by *Cyrena* are the true base of the series.

Clays above the gypsum. The clays above the gypsum are lake deposits. The principal species are *Planorbis planulatus*, *Limnæa strigosa* and *Nystia plicata.* These clays are well developed at Pantin, near Paris, and extend east to Château-Thierry.

The green clays. The green clays, four or five metres thick, overlie the white clays and contain a brackish and marine fauna. These beds at the base are very foliaceous, yellowish and characterized by *Cyrena convexa.* Above, the clays become bluish, and, in some localities, are rich in *Cerithium plicatum*, *C. trochleare* and *Psammobia plana.* The highest layers are green, and often contain concretions of sulphate of strontium. *Cyrena convexa* sometimes occurs. These layers of the green clays are used for the manufacture of tiles. In their southward extension towards Étampes, the green clays become unfossiliferous.

Brie limestone. The green clays are followed by the Brie limestone, a freshwater formation containing, though rarely, *Limnæa cornea*, *Planorbis cornu*, *Nystia Duchasteli* and fruits of *Chara*. The limestone forms most of the plateau of the Brie which lies to the east of Paris. Near Argenteuil, at Sannois and Orgemont, this freshwater limestone is replaced by marine marls with *Cerithium plicatum* and *Cytherea incrassata*.

Sands of Fontainebleau. The sands of Fontainebleau, with a rich marine fauna, overlie the Brie limestone. The sands are best developed in the vicinity of Étampes. They have recently been described[*] in much detail by M. Cossmann and M. Lambert.

Oyster-shell marls. A sudden change from the freshwater horizon of the Brie to marine conditions is indicated by the oyster-shell marls, a littoral deposit at the base of the Fontainebleau sands. These marl beds[†] extend from Paris to Lonjumeau. From that town southward to Étrechy, the deposit becomes arenaceous and forms a friable sandstone. At the outskirts of Paris, near Villejuif, the oyster-shell marls contain quantities of *Ostrea cyathula;* but the larger species, *O. longirostris*, becomes more common to the southward. In addition to these characteristic species of *Ostrea*, *Cytherea incrassata*, *Natica crassatina* and *Cerithium plicatum* are common in the marls.

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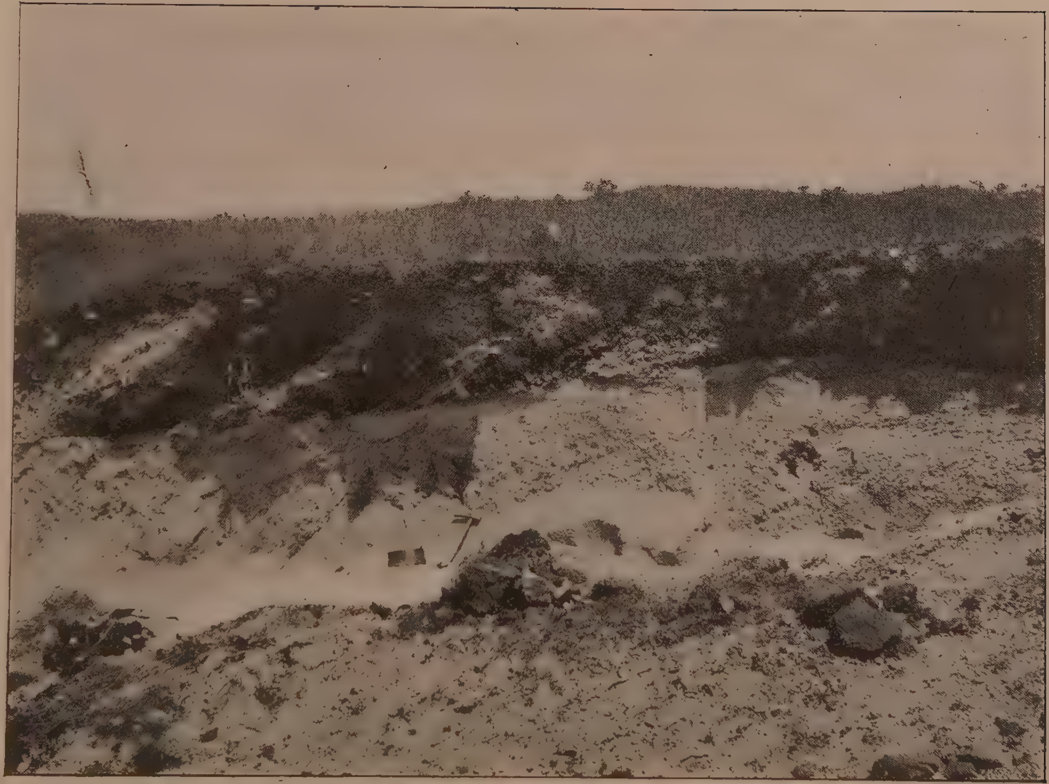
[*] Cossmann et Lambert, Étude Paléontologique et Stratigraphique sur le Terrain Oligocène Marin aux Environs d'Étampes; *Mémoires de la Société Géologique de France*, 3ème série, tome III, 1re partie, 1884.

Cossmann, Déscription de deux espèces nouvelles du tongrien des environs d'Étampes, *Jour. de Conchyliologie*, vol. XXVII, 1879, p. 436, pl. 13.

Lambert, Sables Oligocènes d'Étampes, *Bull. Soc. Géol. de Fr.*, 2ème série, t. IX, pp. 496-499. See also Ibid., 3ème série, t. X, p. 501.

[†] Hébert, Ed., Notice sur les fossiles tertiaires du Limbourg et sur ceux de la couche à *Ostrea cyathula* du bassin de Paris, *Bull. de la Soc. Géol. de Fr.*, 2ème série, t. VI, p. 459, 1849.

Dollfus, Coupe géologique de Chemin de Fer de Mery-sur-Oise, *Bull. Soc. Géol. de Fr.*, 3ème sér., t. VI, pp. 266, 299.



FOSSILIFEROUS SANDS OF MORIGNY IN THE QUARRY AT JEURRE (see page 29).

A local change of elevation during the deposition of these beds is shown by a freshwater layer of white clay at Lonjumeau in the upper layer of the Étrechy sandstone. This layer is characterized by *Paludestrina Dubuissoni.*

Shell marls of Jeurre. The shell marls of Jeurre, a hamlet near Étampes, from which Deshayes obtained many of his Oligocene (lower Miocene) types, are composed of sandy yellowish marls, of no great depth, but very fosssiliferous. In the quarry at Jeurre, of which a photograph, taken by the writer in 1900, is shown opposite page 9, these marls rest on the *Ostrea* bed. Unfortunately, the quarry has not been worked for so long that this contact is now obscured and the shell marl forms most of the floor of the quarry. The characteristic species are *Gastrochæna Rauliniana*, *Corbula subpisum*, *Symdosmya Sandbergeri*, *Cytherea Stampinensis*, *Deshayesia* parisiensis*, *Purpura monoplex*, *Trochus subcarinatus* and *Nummulites Bezançoni.*

Sands of Morigny. The deepwater deposit constituting the sands of Morigny lies above the shell marls at Jeurre. In the photograph of the quarry of Jeurre the sands of Morigny lie to the left of the center, a few feet up from the base. A nearer view of these, on the opposite side of the quarry, is shown in the photograph on the opposite page. At this point the sands are exceedingly fossiliferous. They are especially rich in *Pectunculus* and *Cytherea*, but many of the shells fall to pieces when handled. Near the little hamlet of Morigny the species in the same sands are better preserved, but collecting there, as already explained, is now difficult as the sand pit is overgrown with vegetation. *Pectunculus obovatus*, *Cytherea splendida*, *C. incrassata*, *Cardium tenuisulcatum*, *Lucina Heberti*, *Buccinum Gossardi*, *Pleurotoma belgica*, and especially *Cerithium trochleare*, can still be obtained in this locality.

Sands of Étrechy. The sands and gravels of Étrechy rest unconformably on the sands of Morigny, and indicate a long period of denudation following the deposition of the latter sands.

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*Raulin, Sur un genre nouveau (*Deshayesia*), *Magasin de zoologie*, 2ème sér., t. II, p. 111, pl. 3, 1844.

Only fragments of *Haleotherium* and teeth of *Lamna* are found in this littoral deposit.

Sands of Vauroux. The sands of Vauroux are shallow estuary deposits. At the base are white sands, often micaceous. At Étampes they contain *Lucina Thierensis*, *Corbulomya triangula*, and, at Vauroux, *Syndosmya elegans*. Although species of *Potamides* and *Cyrena* were also found, these beds are not as a rule fossiliferous. The sands of Vauroux were first described by Mayer* in 1864.

Sands of Pierrefitte. The best section of the sands of Pierrefitte is in a sand quarry near the hamlet of Pierrefitte. A photograph of this quarry, taken by the writer in 1900, is shown on the opposite page. This shows the manner in which these fine sands change laterally into coarser material. The sands are very white, and rest on a coarse gravel bed containing eroded fragments of shells. Some estuary species are found, but the fauna is in general marine. *Corbulomya triangula* and species of *Murex* and *Fusus* are very common, but the characteristic species is *Cardita Bazini*. The fauna has been described in detail by Professor Stanislaus-Meunier† and M. Cossmann.‡

Sands of Saclas. The sands and gravels of Saclas are not fossiliferous, except for teeth of *Lamna*. The sands are developed to the south of Étampes.

Fontainebleau sandstone. The sands of Ormoy (Fontainebleau sandstone) are of great economic importance. It is of this stone that Paris is built. Fossils are rare and usually in the form of casts, but, occasionally, when the stone has weathered and crumbled into fine sand, fossils can be obtained. Among these are *Cerithium plicatum*, *Potamides Lamarcki*, *Murex conspicuus*, *Cardita Bazini* and *Cytherea incrassata*.

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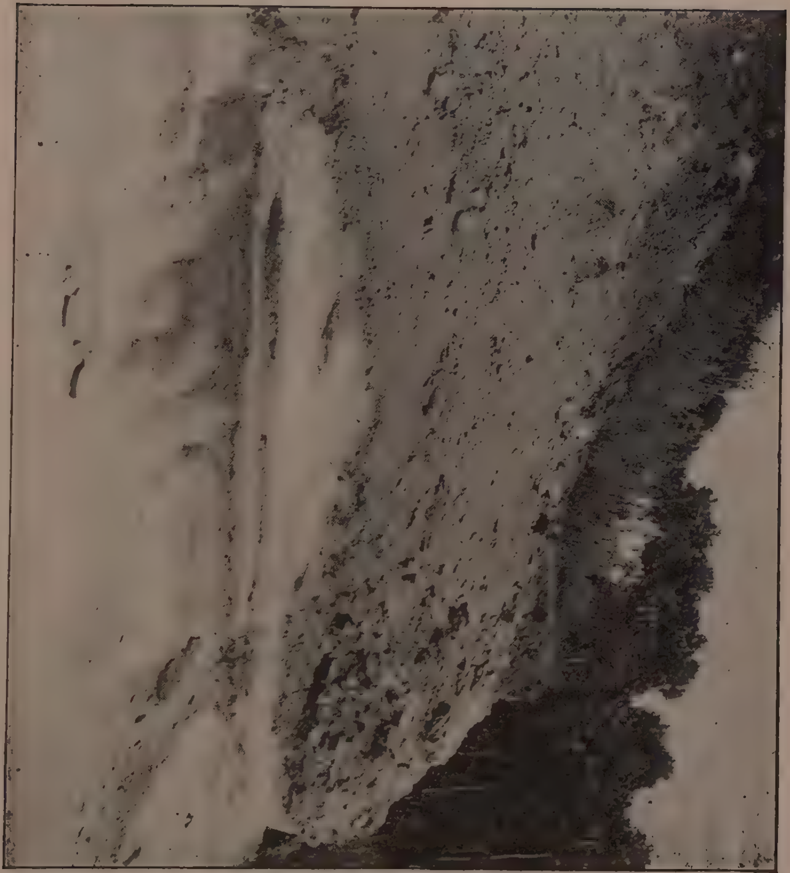
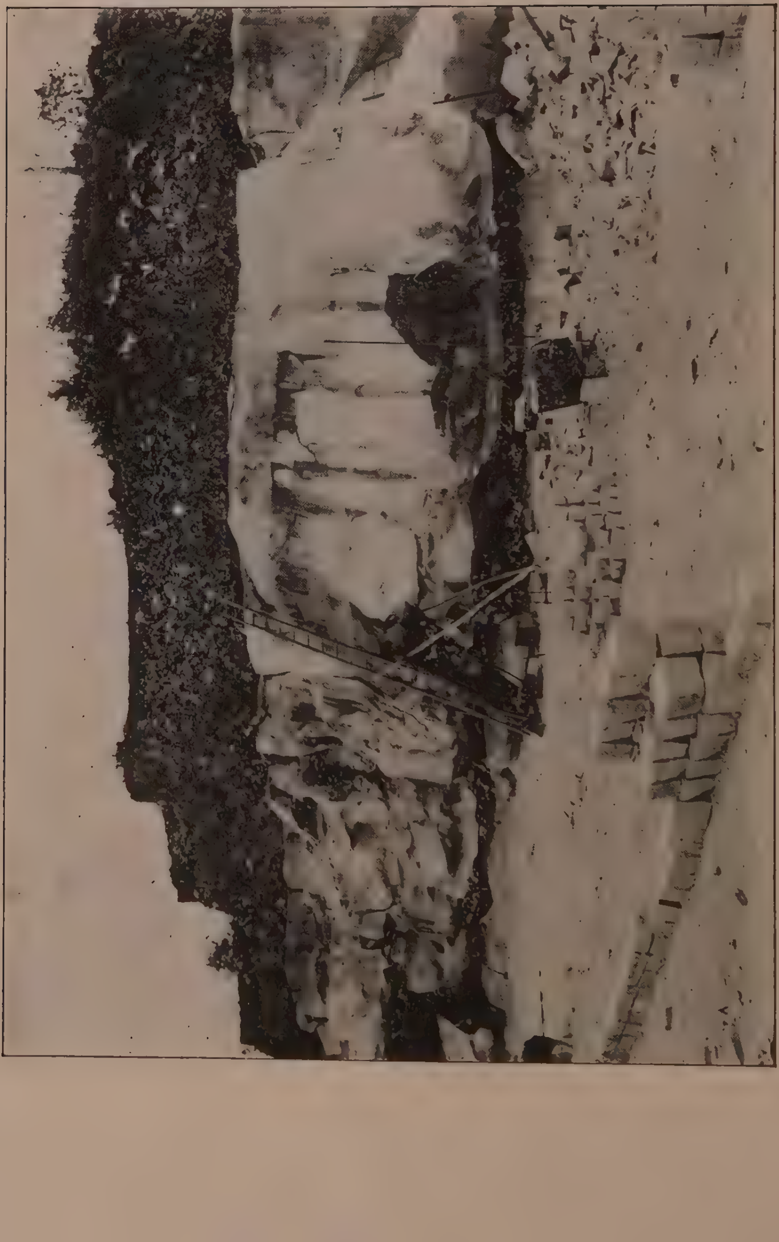
* *Journ. de Conchyliologie*, 1864.

† Sables supérieures de Pierrefitte, *Comptes rendus de l'Acad. des Sci.* t. LXXXIX, p. 611. See also Meunier et Lambert, Récherches stratigraphiques et paléontologiques sur les sables marins de Pierrefitte, près d'Étampes, *Nouv. Arch. du Mus.*, 2ème sér., t. III, pp. 235-268, pl. 13 et 14.

‡ *Mém. Soc. Géol. Fr.*, 3ème sér., t. 3, pt. 1, 1884.



THE QUARRY AT PIERREFITTE (see page 30).



THE QUARRY AT ORSAY (see page 31).

At Chalo-Saint-Mars this marine fauna occurs above a thin lignitic bed with *Potamides Lamarcki* and *Paludestrina Dubuissoni*, thus foreshadowing the deposition of the Beauce limestone, and showing the close connection between the latter and the sandstone.

Beauce limestone. A photograph, taken in 1900 in the quarry at Orsay, is shown on the opposite page. It shows an interesting contact between the marine Fontainebleau sandstone and the freshwater Beauce limestone. The sandstone, which is being quarried for building purposes, is stained with manganese. Directly upon its upper surface, rests the limestone. The latter rock, which is in part silicified and resistant, and in part disintegrated by chemical action, is extremely irregular and cavernous in its structure. No fossils were obtained at Orsay, but *Potamides Lamarcki* and *Cyclostoma antiquum* were collected at other localities in this limestone. At Montmorency the Beauce limestone has undergone silicification to such an extent that millstones occur locally.

The Stampien period. M. Cossmann and M. Lambert have proposed the name Stampien* for the period between the deposition of the sands of Étrechy and those of Ormoy.

The lower sands of Fontainebleau fall under the Rupelian. The Tongrian is represented by the Brie limestone and the clays and, perhaps, the gypsum.

Oligocene in Brittany. Although nearly all of the peninsula of Brittany is of igneous rock, several very local Oligocene deposits occur. These are most important in the vicinity of Rennes. Near that city is a coarse-grained limestone which was correlated by Desnoyers, in 1831,† with the Eocene limestone (calcaire grossier) of the Paris basin.

Limestone of Rennes characterized by Archiacina. Tournouer, however, in 1868,* recognised the true position of this limestone as of the same age as the sands of Fontainebleau. In 1872,† he obtained further evidence from a study of the fauna in more detail. This revealed the presence of *Natica crassatina*, *N. augustata*, *Turbo Parkinsoni*, *Cerithium plicatum*, *C. trochleare* and *Cytherea incrassata*, which proved beyond question the correctness of his earlier conclusion. Vasseur,‡ after a comparative study, in 1881, confirmed the views of Tournouer.

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* From the Latin name for Étampes where these beds are typical. *Mém. Soc. Géol. de Fr.*, 3ème sér., t. 3, pt. 1, 1884.

† Note sur les terrains tertiaires du nord-ouest de la France, autres que la formation des faluns de la Loire, *Bull. Soc. Géol. de France*, 1re série, t. II, p. 414, 4 juin, 1831.

The limestone of Rennes is especially characterized by Foraminifera of the genus *Archiacina*. Other fossils are rare and are found only as casts.

Freshwater limestone and clays. The upper layers of the limestone are brackish and freshwater deposits, with a fauna comprising species of *Potamides*, associated with *Planorbis* and *Limnæa*. These layers are overlaid by clays of freshwater origin containing *Potamides Lamarcki*, *Cyclostoma antiquum* and *Paludestrina Dubuissoni*.

The freshwater limestone and clays of Rennes represent the Beauce limestone of the Paris basin.

Relation of the Rennes fauna to that of Bordeaux. The marine fauna of Rennes has been found to be more closely related to that of Bordeaux than to that of the neighboring Parisian basin. It has also very few species in common with the Belgian Oligocene. But the presence in the Rennes basin of *Natica angustata*, *Turbo Parkinsoni*, *Lævicardium aquitanicum* and other species which are common in the Gironde valley, and total strangers in the basins of northern Europe, has suggested the connection of the Rennes basin, by way of Nantes, with that of Bordeaux.

Oligocene in southwestern France. The Oligocene in southwestern France outcrops in the valleys of the Gironde and the Adour.

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* *Bull. Soc. Géol. de France*, 2ème sér., t. XXV, p. 367, 1868.

† *Ibid.*, t. XXIX, p. 481, 1872.

‡ Récherches géol. sur les terrains tertiaires de la France occidentale, Paris, 1881.

Oligocene of the Gironde valley. The Oligocene of the Gironde valley is strongly developed on the right (northeastern) side of the Garonne. Thus the large areas between the Garonne and the Dordogne rivers, and between the Garonne and the Lot, are made up almost entirely of deposits of this epoch. In addition, there are smaller areas, two north of the Dordogne in the vicinity of Fronsac and St. Emilion, and one at Bourg, near the junction of the Garonne and the Dordogne.

On the left (southwestern) side of the Garonne there are no large areas, but exposures of this formation occur along the valleys of the many small tributaries of the river. Of these outcrops, the most famous are those near Martillac, Saucats, La Brède and Bazas.

On the left side of the Gironde, where it widens, forming the gulf, there are several outcrops as at Lesparre and Pauillac.

A valuable discussion of the Oligocene of the Gironde valley was published in 1895 by M. Fallot* of the University of Bordeaux. M. Fallot's contribution, which has done much in elucidating the stratigraphy and paleontology of the region, has been used as the basis of the following summary:

Section of the Gironde Oligocene. The Oligocene of the Gironde vallley may be regarded as typical near Brazas. The beds are greatly modified near Bordeaux.

	Bazas.	*Bordeaux.*
	3. Grey limestone of Agen.	3. Limestone of Le Son. Shell marl of Lariey. Freshwater limestone near Saucats.
Aquitanian.	2. Sandstone of Bazas.	2. Yellow sandy rock exposed in valleys.
	1. White sandstone of Agen.	1. Marl with *Neritina Ferusacci* (*Nerita picta*).

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[*] Contribution a l'étude de l'étage tongrien dans le Dépt. de la Gironde, *Mém. Soc., des Sci. phys. et Nat. de Bordeaux*, 1895, Tome V, p. 269. See also Esquisse Géologique du Dépt. de la Gironde, *Feuilles des jeunes Naturalistes*, 1889, and Esquisse d'une carte géologique des environs de Bordeaux, 1895.

5. Friable limestone of Agen.
4. Limestone characterized by *Asterias*.
3. Clays with *Ostrea longirostris* and *O. cyathula*.
Tongrian. 2. Freshwater limestone of Castillon and Civrac.
1. Friable sandstone of Fronsac and clays with *Limnæa* and *Planorbis*.

Sandstone of Fronsac. The friable sandstone of Fronsac varies from a loose sandstone to sandy clays, greenish and more or less micaceous. The formation which is typical at Fronsac extends along the valley of the Dordogne and of the Dronne, and is developed principally to the north of Coutras.

Occasionally there is no trace of underlying Eocene, and the sandstone then rests* directly upon the Cretaceous as at La Clotte. At Fronsac, however, the sandstone overlies clays which contain *Limnæa*, *Planorbis* and *Melanopsis mansiana*, a species found in clays above the gypsum in the Paris basin at Pantin. Hence M. Vasseur has coordinated these beds.

The sandstone of Fronsac is, in general, unfossiliferous. The only fragments which can be identified are those of turtles of the genus *Trionyx*, and of the large vertebrate *Paleotherium girondicum*, both forms indicating the lake origin of the sandstone.

Limestone of Castillon and Civrac. The freshwater limestone of Castillon and Civrac is irregularly developed. On the right bank of the Garonne it is important only to the eastward of St. Emilion, as far as Castillon. Along the Dordogne, the limestone also developes to the eastward, and, at Saint-Foy-la-Grande, reaches a depth of 20 metres.

On the left bank of the Gironde, this formation is especially well developed in Médoc, near the town of Civrac. It appears again, though in an argillaceous form, at Vertheuil,† Saint-Sauveur, Blanquefort and other localities.

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* Potier et Vasseur, Sur les formations *infratongriennes* du Bassin de la Gironde, *Soc. Lin. de Bord. C. R. des Séances*, 18 Juillet, 1888.

† Benoist, E., Déscription Géologique et Paléontologique des communes de Saint-Estèphe et de Vertheuil, *Extrait des Actes de la Soc. Lin. de Bordeaux*, t. 39.

When typical the limestone is white and compact, with silicified layers which are sometimes used for millstones.

The fauna is poor. The only really characteristic fossil is *Nystia Duchasteli*, but a few Limnæas have been found. From the presence of *Nystia Duchasteli*, the limestone of Castillon is thought to be the equivalent of the Brie limestone of the Paris basin.

The Ostrea clays. The clays characterized by *Ostrea longirostris* and *O. cyathula* (*O. girondica*) usually precede the limestone with *Asterias.* The oyster beds, themselves, rest either on the limestone of Castillon or on the sandstone of Fronsac. The basal layers of the oyster beds are rich in foraminiferas.

Asterias or Bourg limestone. The limestone characterized by *Asterias* is typical at Bourg. Since this is a coarse-grained, yellowish limestone, Deshayes, Brongniart and others regarded it as equivalent to the Eocene limestone of the Paris basin (calcaire grossier). Des Moulins named the Asterias limestone from the number of *Crenaster lævis* that it contains. But although he observed the close resemblance of the Bourg fauna to that of the oyster marls and green clays of the Paris basin, he still considered the limestone as an Eocene formation.

M. Raulin,* in 1843, in an article on the tertiaries of the Gironde, and in all his later publications, attempted to discriminate between the Bourg limestone and that of St. Micaire, considering the former as Eocene and the latter as Miocene. But Delbos,† Tournouer,‡ Matherson|| and Linder§ proved that these limestones are identical and equivalent to the sands of Fontainebleau of the Paris basin.

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* Nouvel Essai d'une classification des terrains tertiaires de l'Aquitaine, 1848; Resultat des Excursions faites dans le partie O. du Dépt. des Landes, 1864-9.

† Rapport sur une excursion géologiques aux environs de Blaye, *Act. Soc. Linn. Bord.*, t. XIII, 1870.

‡ Recensement des Echinodermes du Calcaire à Asteries, *Extrait des Actes de la Soc. Linn. de Bord.*, t. XXVII, 1870.

|| Notes sur les dépôts tertiaires du Médoc et des Environs de Blaye, etc., *Bull. de la Soc. Géol. de Fr.*, 2ème sér., t. XXIV, p. 197, 4 Fev., 1867.

§ Observations sur les dépôts tertiaires du Médoc et du Blayais dans le Dépt. de la Gironde, 1873, *Comptes rendues de la Soc. Linn. de Bord.*, 1874.

The Bourg limestone is the most important of the lower Oligocene deposits of the Gironde valley. The depth varies from 1 to 60 metres. Near Bordeaux it is quarried as a building stone.

The fossils[*] are usually found only in casts. Some of the more characteristic are *Crenaster lævis*, *Natica crassatina*, *N. angustata*, *Cerithium plicatum*, *C. trochleare*, *Trochus Buchlandi* and *Archiacini armorica.*

Friable limestone of Agen. The friable limestone of Agen is considered by M. Fallot as an eastern extension of the Bourg limestone.

Affinities of the Gironde Tongrian fauna. As already noted, the Tongrian fauna of the Gironde is more closely related to that of the limestone of Rennes, in Brittany, than to any other deposit in France. Its closest affinities are, however, with the Italian fauna.

Aquitanian. The upper Oligocene period (Aquitanian) in southwestern France was characterized by changes in elevation which resulted in alternate freshwater and marine deposits. The fauna has been studied by Basterot,[†] Mayer,[‡] Benoist,[‖] Degrange-Touzin,[§] Fallot and others.[**] The name Aquitanian was given by Mayer to the beds from the geographical name of this section in which the upper Oligocene is so typically developed.

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[*] Fallot, Contr. a l'étude de l'étage tongrien, *Mém. Soc. Sci. phys. et nat. de Bordeaux*, t. 5, 1895.

[†] Déscription géol. du bassin tertiaire au S. O. de la France, in-4°, 1825, (*Extrait des Mém. de la Soc. d'hist. nat. de Paris*, t. 2, pt. 1, 1825).

[‡] Déscription de coquilles fossils des terrains tertiaires inférieurs, *Journ. de Conch.*, 3ème sér., t. IV, p. 170, pl. 9; t. XII, pp. 168-181, 350-361, 1864; Déscription de coquilles fossiles des étages supérieurs des terr. tert., *Ibid.*, t. VII-X, XII, XIV, XVI, 1857-69.

[‖] Catalogue synonymique et raisonné Testacés Fossiles récueilles dans les faluns miocènes des communes de La Brède et de Saucats, pp. 5-78, 265-460, *Actes de la Soc. Linn. de Bord.*, 3ème sèr., t. IX, 1873.

[§] Note sur deux affleurements de Falun situés dans le voisinage du château du Thil. à Léognan (*Extrait des Procés-verbaux de la Soc. Linn. de Bord.*, 4 dec., 1895; Les Scalariidæ fossiles des Terrains Tert. sup. du Sud-Ouest (*Extr. des Actes de la Soc. Linn. de Bord.*, t. XLVIII).

[**] Defrenoy et Elie de Beaumont, Fossiles des faluns de Saucats, Merignac, Léognan, etc., Mém. pour servir à une désc. géol. de la France, t. III, p. 118, 1836.

Linder, Dépôts Lacustres du Vallon de Saucats, *Comptes rendus de l'excursion linniéenne à Saucats*, 1869.

Cossmann, Sur quelques formes nouvelles ou peu connues des faluns du Bordelais, *Ass. fran. pour l' Avancement des Sci.*, 1894-5.

In general the white and the grey limestones of Agen are of freshwater origin, while the sandstone of Bazas is marine. But to the westward, the limestones merge into marine beds.

White limestone of Agen. The white limestone of Agen, in the vicinity of Bazas, although a thin layer, is rich in freshwater fossils such as *Planorbis solidus*, *P. declivis*, *Limnæa pachygaster*, *L. urceolata* and *Helix*. Layers of clay and sand with a brackish fauna occur near Balizac, where *Lutraria sanna*, *Cyrena Brongniarti*, *Cytherea undata*, *Circe Deshayesi*, *Cerithium corrugatum*, *C. girondicum* and *C. plicatum* are also found.

Near Bordeaux the Aquitanian outcrops along a creek which flows through Saucats, Lariey and other hamlets. Tournouer, in 1862, described the lowest bed as a blue marl with *Neritina picta*, *Cerithium calculosum*, *C. plicatum*, *C. pseudothiarella* and *Lucina dentata*. But at the base is a freshwater layer with *Helix oxystoma* and *Planorbis cornu*. This indicates that the whole bed, though largely marine, represents the white limestone of Agen.

The blue marls, characterized by *Neritina picta*, are best exposed in a spring in a vineyard near La Salle (commune of La Brède). The owner obligingly dipped out a quantity of the fine, dark blue marl, which was found to be filled with this beautifully decorated species.

The sandstone of Bazas. The ferruginous sandstone of Bazas* is quarried in many localities as a building stone.

The fauna of this horizon is not varied. The most important species are *Scutella Bonali*, *Psammobia aquitanica*, *Ostrea producta*, *Mactra triangula*, *Arca cardiiformis*, *Turritella Desmaresti*, *T. vasatensis*, *Proto Basteroti*, *Monodonta Araonis* and *Cerithium plicatum*. These fossils usually are found only as internal casts, but, in a few localities, as at Balizac, the shells are well preserved.

The grey limestone of Agen. The grey limestone of Agen, near Brazas, is a thin deposit characterized by *Planorbis* and

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* Degrange-Touzin, Notes Géol. sur le Bazadais, *C. R. des Séances de la Soc. Linn. de Bordeaux*, vol. XLII, 1888, pp. 1-49.

Limnæa. Usually the bulk of the limestone has been much reduced by subsequent erosion. Like the white limestone, although generally of freshwater origin, it comprises also local brackish and marine beds.

Near Bordeaux, the grey Agen limestone is represented in part by the Saucats limestone. Fossils in this are rare. M. Benoist has found *Planorbis solidus*, *P. declivis*, *Helix subglobosa* and other species. The surface is bored by *Pholas*. According to Benoist, the Saucats limestone is the only representative in the Saucats valley of the grey limestone of Agen; but Tournouer, Linder and Fallot include also as equivalents, the shell-marl of Lariey and the freshwater clayey limestone of the Saucats valley.

The shell-marl of Lariey. The shell-marl of Lariey is a very compact, yellowish marl, best observed in an abandoned pit which is not far from the hamlet of Lariey. *Cerithium plicatum*, *Cytherea undata*, *Calyptrea sinensis* and a number of other species were obtained in abundance by the writer from this locality.

Limestone of Le Son. At Le Son, on a ploughed field, a large number of *Cerithium corrugatum* and *Lutraria sanna* were collected. This locality illustrates well the difficulty of correlation in the Bordelais, as on the neighboring field at the same level, are Miocene fossils, and the stratigraphic relations are not revealed by natural sections. This difficulty is increased by the change of beds laterally and vertically from freshwater to marine faunas.

Oligocene of the Adour valley. In the valley of the Adour, the Oligocene outcrops in the vicinity of Dax, St. Paul, St. Sever and on either side of the river between St. Avit and Roquefort. Originally these outcrops were very rich in fossils, but now the supply is exhausted. Fortunately there is a fine collection of types and specimens from the Adour valley in the museum of the University of Bordeaux.

Correlation of the Adour marls. The oldest publication on the basin of the Adour was by Palassou,* in 1784. This contains, however, practically no mention of fossils. Grateloup,[*] from 1834-40, described a large number of species from the Adour marls. In the publication in 1840,[†] in which he figures the species previously described, he notes the Yellow, Blue and White marls of the Adour valley, and refers the White to the Eocene (calcaire grossier) of the Paris basin, the Blue to the lower Miocene and the Yellow to the upper Miocene. In 1855, Delbos[‡] correlated the White marls and the Adour limestone, which are both characterized by *Natica crassatina*, and a portion of the Blue marls with the *Asterias* limestone of the Gironde valley and with the Fontainebleau sands.

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* *Essai sur la minéralogie des monts Pyrenées*, Paris, 1784.

Hébert[||] found further proofs of the parallelism of the Adour marls, with *Natica crassatina*, and the Fontainebleau sands.

Nummulites in the Blue marls. Tournouer[§] called attention, in 1863, to the remarkable abundance of *Nummulites*, especially the species *intermedia*, in the Blue marls of the Adour valley. This is of interest as compared with their rarity in the neighboring valley of the Garonne and with their abundance in the northern Italian basins.

Affinities of the Adour fauna. In general, the fauna of the Oligocene of the Adour is, like that of the Gironde, more closely allied to the species of the Italian deposits, and has but few forms in common with the equivalent beds of the Paris basin.

Oligocene of the Central Plateau. Both lower and upper Oligocene are developed in the southeastern part of the Plateau.

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[*] Tableau des coquilles fossiles des terrains tertiaires des environs de Dax, *Actes de la Soc. Linn. de Bordeaux*, t. VI–VIII; Monographies des coquilles tertiaires du bassin de l'Adour, *Ibid.*, t. X, 1838, et t. XI, 1840.

[†] *Conchy. Fossile des Terr. Tert. du Bassin de l'Adour*, Atlas, 1840.

[‡] Notice géol. sur les terr. du bassin de l'Adour, *Bull. de la Soc. Géol. de Fr.*, 2ème sér., t. IV, p. 712, 1847; Essai d'une désc. géol. du bassin de l'Adour, *Mém. des Sci. phys. et nat. de Bordeaux*, t. I, Jan., 1855; Notice sur les faluns du sud-ouest de la France, *Bull. de la Soc. géol. de France*, 2ème sér., t. V, p. 417, 1848.

[||] *Bull. Soc. Géol. Fr.*, 2ème sér., t. VI, p. 466, 1849.

[§] Note sur la presence des Nummulites dans l'étage à *Natica crassatina* du bassin de l'Adour, *Bull. Soc. Géol. de Fr.*, t. XX, 2ème ser., 1862-3, p. 649.

Fontanne's section. M. Fontanne,* in 1884, made the following section of this region:

5. Conglomerate.
Aquitanian. 4. Grey clays and limestone of Salindres. (*Cyclostoma antiquum* and *Rhinoceros*).
3. Calcareous sandstone (plants).
Tongrian. 2. Limestone of Montredon (*Planorbis* and *Limnæa*).
1. Limestone and marls of Monteils (*Cyrena semistriata*).

In the northwestern part of the Plateau, near La Limagne and Montbrison, are brackish and freshwater beds. The former mark the period during which the basins in which they rest were connected with the Paris basin; the latter are isolated deposits of lacustrine origin.

In the eastern portion of the Plateau, in the vicinity of Velay, freshwater limestones with *Planorbis* and *Limnæa* overlie the Eocene.

Oligocene of the Saône and Rhone valleys. Freshwater Oligocene beds, usually limestones, with *Helix Ramondi*, are well developed along the valley of the Saône, as at Dijon, Brognon and Belfort. In Languedoc, in the southwestern portion of the valley of the Rhone,† are upper Oligocene marine and brackish clays with *Potamides.*

Section of the Oligocene of the Mainz basin. The Oligocene of the Mainz basin consists of:

8. Limestone (*Corbicula Faujasi*).
7. Limestone (*Cerithium cinctum*, *C. plicatum*, *Potamides Lamarcki*).
6. Sandstone (imprints of leaves of *Quercus*, *Ulmus*, etc.).
5. Freshwater and brackish clays (*Cyrena semistriata*, *Cerithium plicatum*, *Potamides Lamarcki*, *Planorbis cornu*, *Anthracotherium alsaticum*).

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* Déscription sommaire de la malacologie des formations saumâtres et d'eau douce du groupe d'Aix, 1884.

† Fontanne, Études stratigraphiques et paléontologiques pour servir a l'étude de la période tertiaire dans le bassin du Rhone, 1875-1881.

4. Marine sands of Elsheim (*Pectunculus obovatus*, *Avicula Stampinensis*, *Cythereæ incrassata*).
3. Septaria clays (*Natica crassatina*, *Leda Deshayesiana*, *Cytherea splendida*).
2. Marine sands of Alzey and Weinheim (*Natica crassatina*, *Pectunculus obovatus*, *Cerithium Boblayei*).
1. Oyster beds (*Ostrea cyathula*, *O. callifera*).

In 1806, Faujas de Saint-Fond described the fossils of this basin.* This monograph was followed by those of Braun,† Weinkauff,‡ Sandberger|| and Lepsius.§ The recent work of Lepsius is of special value for both paleontological and stratigraphical reference.

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* Des coquilles fossiles des environs de Mayence, *Ann. du Muséum*, t. VIII, p. 372, also in-4°, Paris, 1806.

† Darstellung der geol. Verhältnisse des Mainzen Tertiärbeckens u. seiner fossilen Fauna u. Flora, in *Walchner's Geognosie*, 1850.

‡ Septarienthon im Mainzer Becken, *N. Jahrt. Mineral.*, p. 177, 1860.

|| Die Conchylien d. Mainzer Tertiärbeckens, Wiesbaden, in-4°, 460 pp., 36 pl., 1863.

§ Das Mainzer Becken, Darmstadt, 1883.

PART II.

THE OLIGOCENE OF THE SOUTHERN UNITED STATES.

General Extent.

The extent, as now determined, of the Oligocene in the Southern States is shown on the map on the opposite page.

The Vicksburg limestone. North of the large area of Vicksburg limestone, which passes through Georgia, dips into Florida, and, crossing Alabama and Mississippi, ends in the Vicksburg bluff, are isolated outcrops of the same rock noted by Prof. Harris. Their position in surrounding Eocene recalls the similarly situated Oligocene areas of Ecouen and Montmorency in the Paris basin. That these are remnants that have resisted the erosion which has removed the rest of the original northern extension of the present Vicksburg sheet is more than probable. They indicate that the limestone formerly extended at least as far north as Macon and Montgomery and to the north of Jackson. The most western exposure of Vicksburg is north of Harrisonburg, Louisiana, in the vicinity of Rosefield.

The southward extension of this limestone, as surface rock, is not great, since its extent is concealed beneath later deposits and the waters of the Gulf of Mexico. Borings at St. Augustine have shown that the Vicksburg has there a depth of 1,066 feet. The indications are that the entire peninsula of Florida rests upon a plateau* of this limestone, which formerly extended continuously to Cuba and the Bahamas, but has since been dissected and channeled by the erosive action of the Gulf Stream.

Chattahoochee limestones and clays. The Chattahoochee argillaceous limestones and clays are chiefly developed in Florida and in southern and southeastern Georgia. They also extend a trifle beyond the western state line of Florida and Alabama.

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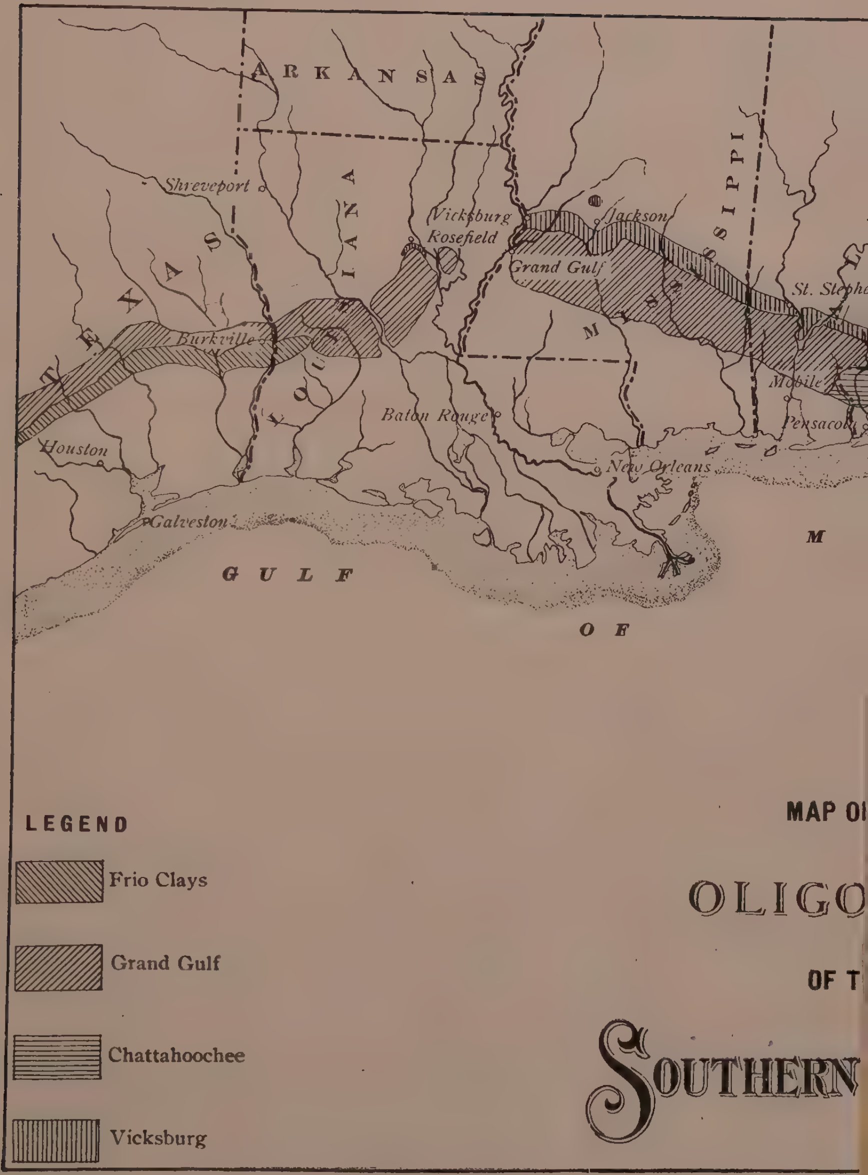
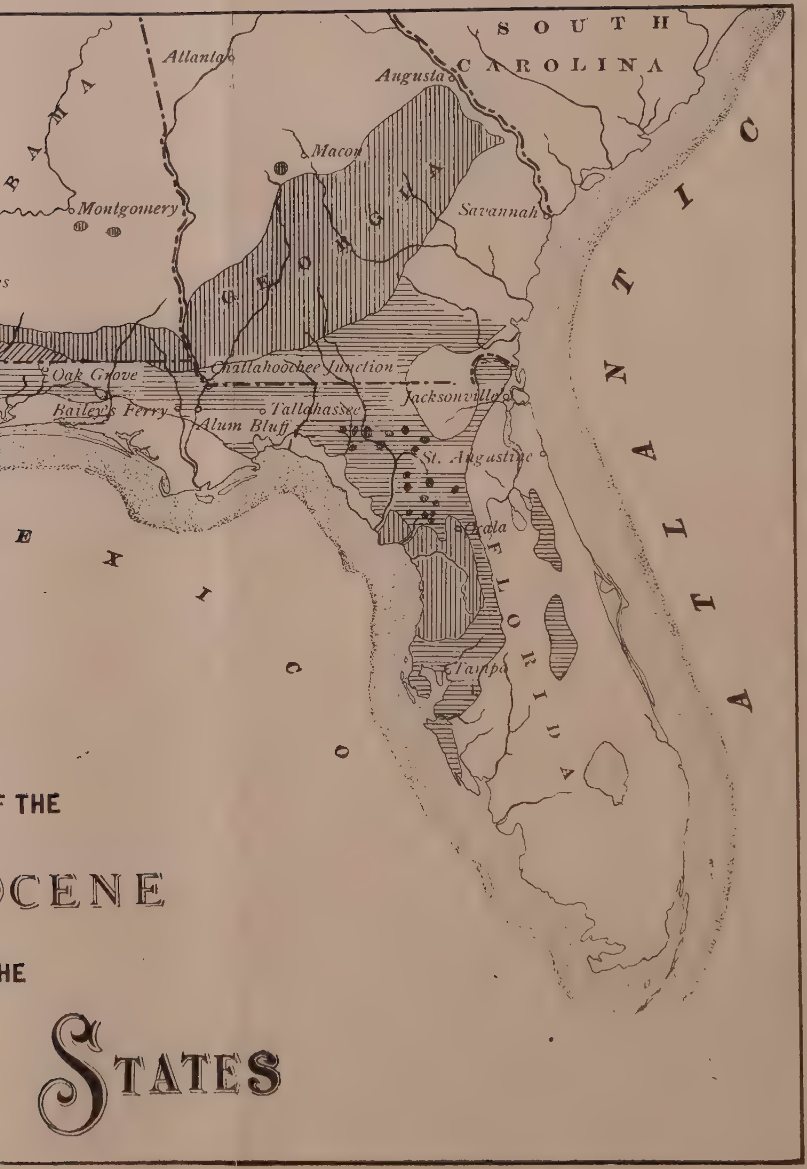
*Dall, *Bull. U. S. Geol. Survey*, No. 84, p. 181.

Bull. Amer. Pal.



Pl. 25


SOUTH
CAROLINA
Atlanta
Augusta
BAMA
Macon
Montgomery
GEORGIA
Savannah
Oak Grove
Chattahoochee Junction
Jacksonville
Bailey's Ferry
Tallahassee
Alum Bluff
St. Augustine
Ocala
Tampa
FLORIDA
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Grand Gulf sandstones. The Grand Gulf sandstones first appear in southern Alabama near the center of the state along the Florida line. They widen rapidly beyond the western limits of Florida and extend to the Mississippi, forming the bluff at Grand Gulf. Beyond the Mississippi they reappear in Louisiana, at Sicily Island, and again near Harrisonburg. Crossing the state from that locality in a southwesterly direction, the sandstones enter Texas and extend certainly as far as the Brazos river.

Frio clays. The Frio clays are characteristic of Texas, but they extend eastward into southwestern Louisiana where they thin out and disappear.

Conditions of Deposition.

Physical Geography during the Vicksburg period. While the deposition of the Vicksburg limestone was taking place over a wide area of the sea-floor, the waters of the Gulf of Mexico and of the Pacific Ocean were probably confluent across the Isthmian region, as Mr. Alexander Agassiz has shown. Florida was at first entirely submerged. At the close of the period, islands near Ocala were upraised, as Dr. Dall has proved by the presence of land shells in the Ocala limestone. The southwestern extremity of the continent at the beginning of the Vicksburg period was, presumably, near the present sites of Macon and Augusta.

Deflection of the equatorial current. At the close of the Eocene, an elevation of the Isthmian region took place which cut off the Gulf of Mexico from the Pacific Ocean. The equatorial current, that had formerly swept across into the Pacific, was deflected to the north and northeast, along the shores of the continent. The shore line was upraised, exposing a portion of the Vicksburg limestone. Florida appeared as a chain of islands. The return current, as Dr. Dall has shown, passed between these islands and the shores of the continent through a broad strait for which Dr. Foerste proposes the name of Okefenokee,* as it occupied, in part, the region of Okefenokee swamp between southern Georgia and

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* Chipola Miocene, *Amer. Jour. Sci.*, 3rd ser., vol. 46, 1893, p. 245.

Florida. Dr. Foerste surmises that this strait was at first compartively shallow, but was scoured out by the erosive action of the current.

Depositions in the Chattahoochee and Mississippi embayments. Meanwhile, the Chattahoochee river brought down sediments which were mingled with shells along the shores and with material brought by the ocean current, and its embayment* was the principal scene of deposition of the Chattahoochee limestones and clays.

In a similar manner, the Grand Gulf deposits were made in the Mississippi embayment. The latter depositions, then, as now, were singularly lacking in organic remains.

Tropical fauna of Chipolan waters. The warm current bathing the shores made the Chipola period most favorable for molluscan life. Species introduced by this current from the Antillean waters† established thriving colonies.

Intrusion of cold current. Introduction of Chesapeake species. The continued elevation, however, gradually resulted in the deflection eastward and off-shore of the warm current, allowing the passage alongshore of a cold current from the northeast. Dr. Foerste‡ supposes the cold current to have branched at the southeastern extremity of the continent; one portion flowing past the Florida islands, and the other bathing the continental shores. This change was followed by the disappearance of the Chipola fauna, and the cold water fauna of the Chesapeake Miocene was introduced.

Dr. Dall notes|| the reappearance of the tropical Chipola forms under the more favorable conditions of the Pliocene of the Caloosahatchie.

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*Johnson, the Chattahoochee Embayment, *Bull. Geol. Soc. Amer.*, vol. 3, 1892, pp. 128-132.

† Dall, *Bull. U. S. Geol. Survey*, No. 84, 1892, p. 30.

‡ *Amer. Jour. Sci.*, 3rd ser., vol. 46, 1893, p. 246.

|| Dall, *Bull. U. S. Geol. Survey*, No. 84, 1892, p. 30.

The Oligocene Series in Detail in the Several States.

Florida.

Vicksburg Group. Vicksburg limestone. Orbitoides limestone, with characteristic Vicksburg fossils, forms a large part of the country rock of northern central Florida. The exact distribution is not yet definitely known, because the lithological differences of the Vicksburg and later limestones are so trifling that a faunal study is necessary to distinguish them. The rocks throughout the state are also much obscured by the dense sub-tropical vegetation and by superficial sands. The distribution of the Vicksburg in Florida, based on recent investigation by Dr. W. H. Dall* and others in that state, is sketched on the accompanying map, opposite page 42. In 1850 and 1851, Prof. J. W. Bailey described† this rock as a white Orbitulite limestone observed between Palatka and Tampa. Recent investigations show that it extends south nearly to the Hillsboro river. To the north it occurs in the region of Gainesville and Ocala, but, at these localities it is surrounded by extensive Chattahoochee deposits. At Ocala, the Orbitoides limestone was bored into for 350 feet, and its base not reached. At St. Augustine, as already noted, where this rock lies 212 feet below the surface, borings passed through 1,066 feet of the limestone without reaching the base.

Lithologically, the Orbitoides limestone is a porous rock of varying purity. It is usually rather soft when quarried, but hardens on exposure to the air. Certain strata are often rendered cherty, or even changed to pure flint, by the infiltration and deposition of silex in solution. Others are transformed to gypsum by the action on the calcium carbonate of water with sulphur, derived from decaying vegetation, in solution. An analogous chemical action results in the formation of phosphatic beds. The later limestones in the state are also subject to these modifications to a greater or less degree, dependent on the purity and solubility of the rock. Underground drainage and its attendent results, such as sink holes, the disappearance of surface rivers, temporary lakes and natural bridges, are characteristic of the limestone areas.

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* *Loc. cit.*, pp. 156-7.

† *Amer. Jour. Sci.*, 2nd ser., 1851, vol. 2, p. 86; *Smithsonian Contr. Knowl.*, 1850, vol. 2, No. 8, p. 19.

The fauna of the Orbitoides rock comprises many of the characteristic Vicksburg species such as *Orbitoides mantelli*, *Pecten poulsoni* and *P. perplanus*. As in the Gulf States, a large part of this limestone is formed wholly of the remains of *Orbitoides*.

Ocala nummulitic limestone. In the vicinity of Ocala, a yellow, friable limestone, containing nummulites, rests upon the Orbitoides rock. Quarries at Ocala have exposed some twenty feet of the nummulitic limestone without reaching the base. The area of surface exposure is limited, extending from Ocala almost to the coast. These beds were first described by Prof. John Le Conte.* He writes, "The whole of this portion of the peninsula appears to have been originally composed of a mixture of sand and shell limestone, probably of the Eocene period. The limestone comes to the surface almost everywhere; in some cases it is composed of nearly pure carbonate of lime ,in others silicification has taken place. But, in all cases where its structure can be made out, it consists of a mass of conglomerate shell."

T. A. Conrad,† in 1865, identified *Globulus alveatus* Con., *Venericardia prima* Con. and *Dosiniopsis alta* Con. from specimens of Ocala limestone. He remarks that these are all Eocene species of California, Maryland and New Jersey, and refers the Ocala rock to the period of the Shark River marl of New Jersey. The fauna is now found also to include a number of species occurring in the Tampa and Chipola beds, but a greater number are common to the Orbitoides limestone of which Ocala is a slightly later phase. The Ocala limestone was first distinguished from the Orbitoides rock by Prof. Heilprin. In 1862, masses of rock containing foraminiferal remains were found by Mr. Willcox on the Cheeshowiska River. The species was identified by Prof. Heilprin as a true nummulite, the first of the genus found in

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* Optical Phenomena of the Silver Spring, *Amer. Jour. Sci.*, 2nd ser., vol. 31, p. 11.

† *Proc. Acad. Nat. Sci.*, Phila., 1865, p. 184.

America, and named by him, *Nummulites Willcoxi*.[*] He found later another species of the same genus, *N. floridensis*, which is less common than the former. The fragments of nummulitic rock were bordered by a fringe of Pleistocene limestone with recent freshwater shells indicating that the older deposit had been worked over, but the latter was subsequently found in place 15 miles from the original locality, and has since been observed in several places and identified with the Ocala limestone. The existence of Nummulitic beds in the United States was thus definitely established by Prof. Heilprin.[†] At Wheelers, on the Homosassa River, a few miles from the Nummulitic beds, Prof. Heilprin found a tough, horizontal limestone, full of *Miliolidæ*. The near association of the miliotitic and nummulitic beds leads Prof. Heilprin to consider them almost equivalent.

Beds analogous to the nummulitic deposits of central Florida have been found silicified at Hawkinsville, Georgia, and on the Suwanee river in Florida.[‡]

Chattahoochee Group. Langdon's discovery of the Chattahoochee beds. In 1887, Mr. D. W. Langdon discovered on the Chattahoochee River, ~~beneath~~ above the Orbitoides limestone, a formation which he described as an "argillaceous and sandy limestone, alternating with strata of purer character. Contains a *Pecten* and an *Ostrea* very close to our recent *Virginica*. This may be termed the Chattahoochee group, as it is well developed there, and along the eastern river bank for the next ten miles."[‖]

This deposit first appears nine miles above Chattahoochee Junction and continues in sight to Rocky Bluff, where it disappears. After Mr. Langdon's discovery of the Chattahoochee group, beds belonging to this series, but previously confused with the Orbitoides limestone, were found to extend not only over the greater part of northwestern Florida, but also to form, in part, the country rock of the central portion of the peninsula. The extent of the Chattahoochee is indicated on the map.

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[*] Occurrence of Nummulitic deposits in Florida, *Proc. A. N. S.*, July, 1882. (Species described earlier by Morton and Conrad as belonging to the genus *Nummulites* were really *Orbitoides*).

[†] Explorations West Coast of Florida, *Trans. Wag. Free Inst. Sci.*, vol. 7, 1887.

[‡] Dall, *Loc. cit.*, p. 105.

[‖] Geoligical Section Chattahoochee River, in *Geol. Survey Ga.*, 1890-91, also *Amer. Jour. Sci.*, 3rd ser., 1889, vol. 38, p. 324.

The Orbitoides and Chattahoochee limestones vary in their surface characteristics, but the difference is only one of degree. The Chattahoochee is much less porous, denser, more argillaceous and, hence, less soluble than the Orbitoides. As a result, the drainage in the Chattahoochee areas is more on the surface instead of underground, as in the older limestone areas. The more variable beds of the Chattahoochee rock also gives rise to a more rugged topography, which forms a contrast with the level Vicksburg areas.

The Chattahoochee series in central Florida. The Hawthorne beds. In 1887, Dr. Dall described* certain beds of broken-up phosphatic rock, enclosed in a younger matrix, found overlying the Vicksburg group in the vicinity of Gainesville. Beds of the phosphatic rock were later found in place on hilltops near Archer. Dr. Dall has named them the Hawthorne beds, since they are quarried at that town. They usually comprise a greenish clay at the top, followed by ferruginous gravel and phosphatic oolite. The Hawthorne beds constitute the base of the Chattahoochee group in central Florida.

The Orthaulax bed. Dr. Dall proposes the name Orthaulax bed† for the siliceous outcrop on the shores of Tampa Bay, which has been generally called the Tampa silex bed. The original limestone has been much modified by the infiltration and decomposition of silex and, locally, by disintegration into marls. The deposit extends up the Hillsboro and Manatee Rivers. It was observed at the Falls of the Hillsboro River, in 1846, by Lieut. John H. Allen, who described‡ it as a dark, siliceous rock, noted for the beauty of its chalcedonized fossils. He distinguished clearly between this rock and the overlying Tampa limestone, while Conrad's description* in the same year is obscure in this respect.

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* *Loc. cit.*, p. 108; see also *Amer. Jour. Sci.*, 3rd ser., 1887, vol. 34, p. 164.

† *Ibid.*, p. 107.

‡ Geology of Tampa Bay, *Amer. Jour. Sci.*, 2nd ser., vol. 1, 1846, pp. 38-42.

Prof. Heilprin† speaks of a siliceous rock at Ballast-Point, containing quantities of *Cerithium*. But Dr. Dall‡ subsequently found that the true siliceous rock does not contain *Cerithium* (*hillsboroensis*) and thinks the stratum mentioned by Prof. Heilprin was probably a cherty layer of the Tampa limestone, overlying the Orthaulax bed.

Bailey's infusorial earth. Prof. J. W. Bailey,‖ in 1850, found in the vicinity of Tampa Bay an infusorial layer which he compared with similar beds in Virginia. Dr. Dall, in 1891, observed this bed near Ballast Point, and found it to be a siliceous marl, formed by local decomposition of the original Orthaulax beds. In the samples examined microscopically, no infusorial remains were found.§

White Beach sand rock. The White Beach sand rock of Little Sarasota Bay is a waterworn limestone, covered with superficial recent layers of sand. The fauna resembles that of the Orthaulax bed, and also contains species of the Chipola marls.**

The Tampa limestone. The Tampa limestone which outcrops along the shores of Tampa Bay, underlies the city of Tampa, and extends to the Hillsboro and Manatee Rivers, was referred until recently to the Vicksburg period. An outcrop of this rock at Fort Brooke, Tampa Bay, was described by Lieut. J. H. Allen†† in 1846, as a white limestone, typically hard, but with occasional softer beds. Over wide areas it retains its general lithological characteristics. The country which it underlies is characterized by sink holes and subterranean streams. Many lakes and ponds in the interior rest upon the limestone. At certain localities the deposit is fossiliferous.

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* *Ibid.*, vol. 2.

† Explorations West Coast, *Trans. Wag. Free Inst. Sci.*, vol. 1, 1887.

‡ *Loc. cit.*, p. 107.

‖ *Amer. Jour. Sci.*, 2nd ser., vol. 10, p. 282; also *Microscop. Obs. Smithsonian Contr. Knowl.*, 1850, vol. 2, No. 8, p. 19.

§ *Loc. cit.*, pp. 116-7.

** *Loc. cit.*, p. 114.

†† Some Facts respecting the Geol. of Tampa Bay, *Amer. Jour. Sci.*, 2nd ser., vol. 1, 1846, pp. 38-42.

Referred by Conrad to the Upper Eocene. In the same year, T. A. Conrad* visited the region and traced the limestone from Fort Brooke to the Hillsboro and up the Manatee. He concluded that the rock extends throughout the peninsula as far south at least as Tampa Bay. He remarks that the fossils bear no resemblance to either Miocene or Eocene species, but that the formation will probably prove to be an upper member of the Eocene. Eight species from the Tampa limestone at Ballast Point were described by Conrad† a short time later. Among these is *Bulimus floridanus*, which he notes as the first fossil land shell found in American Tertiaries. The other species are all marine, and include *Nummulites floridanus*, *Bulla petrosa*, *Nucula tellinula*, *Cytherea floridana*, *Venus penita* and *V. floridana*.

The basal layers of the Tampa limestone contain few fossils, but, in the upper beds, *Natica amphora* and *Venus penita* are said by Dr. Dall to be very common. Lithodomus borings characterize the upper surface.

Correlated with the Vicksburg formation. The occurrence of the foraminifer described as *Nummulites floridanus* led Conrad to correlate the Tampa with the Vicksburg limestone, since the latter contained a species described by Morton as *Nummulites mantelli*, and was called the American Nummulitic formation.‡

Prof. Tuomey‖ explored the Florida coast in 1850, and agreed with Conrad that the limestone of Tampa and Fort Brooke represents an older Tertiary deposit.

The Coralline theory of Agassiz and Le Conte. Disregarding the conclusions of the preceding geologists, Prof. Agassiz, after a visit to Florida in 1861, pronounced the country rock to be a recent coralline formation.* In his monograph on the reef, Prof. Agassiz speaks of his surprise and delight at finding that the solid foundation of the mainland consists of the same identical modifications of the coral rock which form the keys.

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* Obs. on the Geol. of a part of East Florida, *Ibid.*, vol. 2, pp. 36-48.

† Descriptions of new species of organic remains from Upper Eocene Limestones of Tampa Bay, *Ibid.*, vol. 2, pp. 399-400.

‡ Both these generic determinations were later shown to be erroneous, and Prof. Heilprin described the first true nummulite found in this country in 1884.

‖ Notice of the Geol. of the Florida Keys and the Southern Coast of Florida, *Amer. Jour. Sci.*, 2nd ser., vol. 11, pp. 390 ff.

Prof. Joseph Le Conte expounded the coralline hypothesis with such skill that, for thirty years, it remained the established theory. He remarks‡ that Florida has been thought to consist of the southward prolongation of the Georgia and Alabama Eocene, and its shell limestone to bear a general resemblance to the White Limestone. It is, however, a remarkable fact that most of the peninsula and the keys are of recent origin, the work of corals still living in the vicinity. Whether any Eocene beds occur at Tampa is still problematic.

Coralline theory refuted by Smith in 1881. The observations of Mr. E. A. Smith, in 1881, compelled Prof. Le Conte‡ to modify this view, and, in 1883, he limited the area of coralline formation to the region south of the Everglades.||

Mr. Smith§ traced the Vicksburg limestone by outcrops from Jackson County in northwestern Florida to a point below Ocala. Since Conrad and Tuomey had found in the Tampa region limestone which they referred to the Vicksburg, Mr. Smith concludes that "almost the whole State of Florida from the Perdido River on the west, eastward and southward, including the middle and western parts of the peninsula, certainly as far south as the latitude of Tampa Bay, and probably, as far south as the latitude of Charlotte Harbor, has, for its underlying formation, the white

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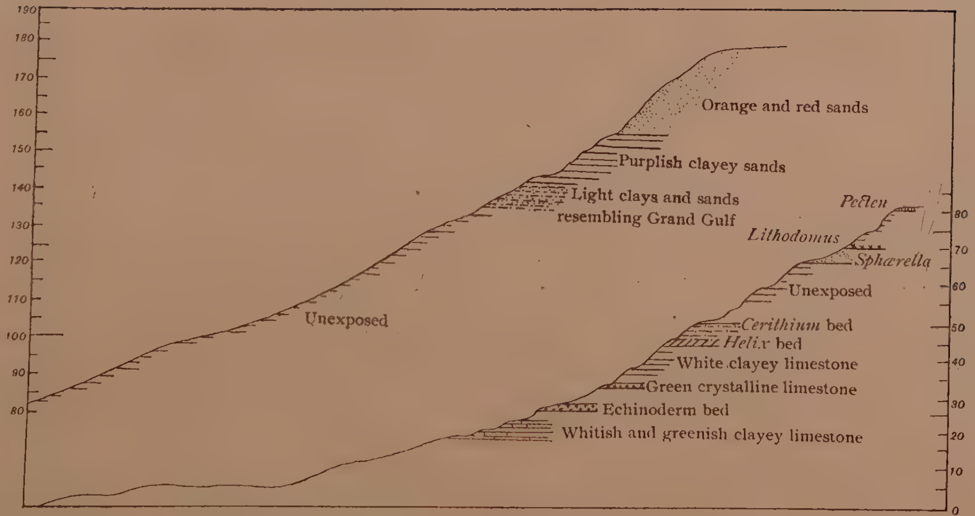
[*] Report on the Florida Reefs, *Mem. Mus. Comp. Zool.*, 1880 (pub. by Alex. Agassiz).

[†] On the Agency of the Gulf Stream in the Formation of the Peninsula and Keys of Florida, *Amer. Jour. Sci.*, 2nd ser., vol. 23, pp. 46 ff.

[‡] *Science*, Dec. 14, 1883.

[||] The coral area is now considered as comprising only the border region on the south and southeast of the peninsula. The coral beds in Tertiary times were evidently sporadic and did not form any extensive reefs.

[§] The Geol. of Florida, *Amer. Jour. Sci.*, pp. 292 ff.



SECTION AT OLD CHATTAHOOCHEE LANDING.

or Orbitoides limestone of Vicksburg age.*

Much of the limestone referred by Mr. Smith to the Vicksburg has proven of somewhat more recent formation, but he refuted the coralline theory by proving the existence of Tertiary deposits on the peninsula.

Tampa limestone referred by Heilprin to the Santo Domingo Miocene. Prof. Heilprin,† in 1887, referred the Tampa limestone to the Miocene because he found a close resemblance between the species of the Florida rock and those of the Santo Domingo Miocene beds. During the same year, Dr. Dall also noted this affinity of the fauna of the Tampa limestone and that of the Antillean Miocene.‡

The Chattahoochee series in northwestern Florida. Section at Old Chattahoochee Landing (see page 52). A number of sections were made at various bluffs along the Appalachicola River by Prof. Harris in 1901. Of these sections, the most northern was taken at Old Chattahoochee Landing, about one mile above the railroad bridge, on the eastern side of the river, following the road from Rena Harding's ferry to Chattahoochee village. The lower portion, from the base up to 83 feet, was run with a Dumpy level, the upper portion by Locke level. The river surface was about 23½ feet below the railroad rails when the section was made. From this level as a base, the height of the bluff was found to be 178 feet.

The rocks of the Chattahoochee series in this locacity are all light colored, and often poorly consolidated. The greenish layers are commonly soft clays, but even these are harder than the majority of the white beds. A layer with Helices was noted by

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* To explain the absence, according to this theory, of Grand Gulf deposits in Florida, Mr. Smith suggests that the western coast line of the Eocene peninsula was much to the westward of the present shore line, and that the Grand Gulf deposits are now submerged, as is indicated by the submarine shelf extending far out into the Gulf of Mexico.

† Exploration of the West Coast of Florida, *Trans. Wag. Free Inst. Sci.*, vol. 1, 1887.

‡ Notes on the Geol. of Florida, *Amer. Jour. Sci.*, 3rd ser., 1887, vol. 34, pp. 161-170.

Prof. Harris at an elevation of about 43 feet. The presence of these land shells recalls the mixed fauna of the Tampa and Ocala beds, and, as there, presumably indicates an increase of neighboring land areas.

A number of fossils were obtained, chiefly from the Echinoderm, *Cerithium*, *Lithodomus* and *Pecten* beds, but nearly all in the form of casts. Among these are *Conus* cf. *planiceps*, *Cerithium*, *Ampullina* cf. *amphora*, *Ostrea*, *Loripes*, *Pecten* (2 species), *Modiolus*, *Lithodomus*, *Hemicardia*, *Gastrochæna*, *Divaricella* and Echinoderms. It is of interest to compare this section with one taken in the near vicinity by Dr. Dall* in 1895. In the latter section the fossiliferous zone was limited to four feet; while in the former, fossils were found at intervals through a depth of fifty-seven feet, the principal fossiliferous layers being the *Pecten*, *Sphærella*, *Cerithium*, *Helix* and Echinoderm beds.

Section at Aspalaga Bluff (*see page 55*). A land leveled section was taken several miles south of Old Chattahoochee Landing, at the northern end of Aspalaga Bluff. At this point the total height above water level was found to be 155 feet.† Three principal fossiliferous zones were noted, the *Madrepora* bed, 26 feet from the base; a bed of whitish-yellow limestone at an altitude of about 32 feet, resting on the coralline bed and containing a quantity of small fossils; and a layer with casts at an altitude of 62 feet.

Above 84 feet the bluff is almost wholly covered. Limestone with *Pecten* and *Placuna*, at an altitude of about 145 feet was, noted *in situ* by Prof. Harris. This indicates that the limestone mentioned by Dr. Foerste as occurring 130 feet above water level was also in place, and not transferred as Dr. Dall suggests.‡

No real discrimination could be made, at least in the region of sectioning, between the so-called "Aspalaga clays" of Mr. Johnson‖

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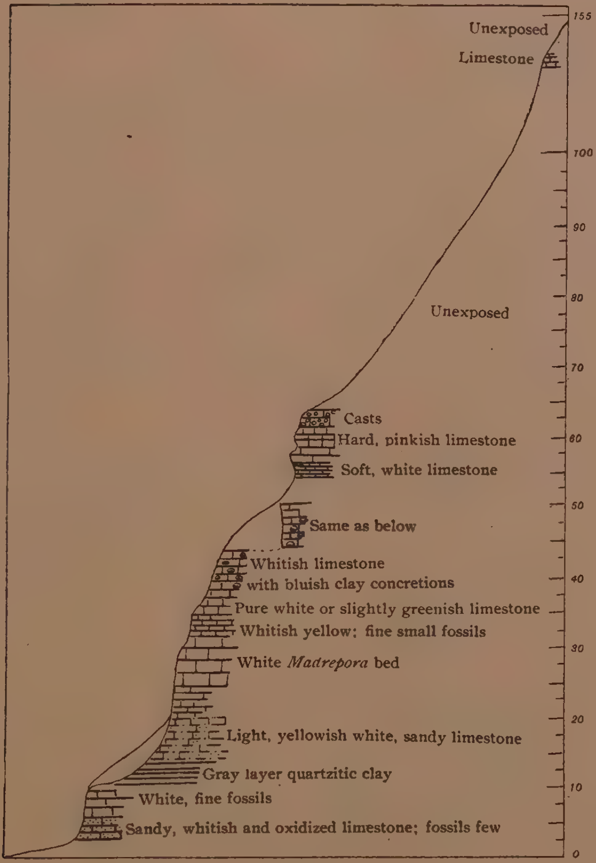
* Dall and Stanley-Brown, *Bull. Geol. Soc. Amer.*, vol. 5, 1895, p. 152.

† The intervals from 10 to 20 and from 43 to 50 feet were covered with talus in the direct line of sectioning. The beds thus concealed were observed at one side of the line and are indicated in the section within the talus slopes.

‡ *Bull. Geol. Soc. Amer.*, vol. 5, 1895, p. 154.

‖ *Ibid.*, vol. 3, 1892, p. 129.


155
Unexposed
Limestone
100
90
80
Unexposed
70
Casts
Hard, pinkish limestone
60
Soft, white limestone
50
Same as below
Whitish limestone
with bluish clay concretions
40
Pure white or slightly greenish limestone
Whitish yellow; fine small fossils
30
White *Madrepora* bed
20
Light, yellowish white, sandy limestone
Gray layer quartzitic clay
10
White, fine fossils
Sandy, whitish and oxidized limestone; fossils few
0

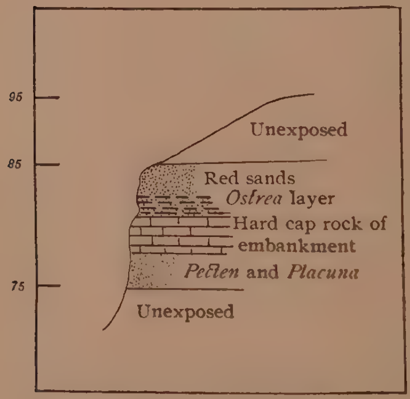
SECTION AT ASPALAGA BLUFF.

and the Chattahoochee limestone. The clays appear rather to be merely argillaceous beds of the limestone, which becomes again more calcareous above.

A section taken at the highest point of Aspalaga Bluff by Dr. Dall gives a total thickness of 75 feet above water level. Of this, the lower 40 to 50 feet are referred to Chattahoochee limestone; the succeeding 20 feet, to bluish green marl (Aspalaga clay of Johnson) with *Ostrea* and *Pecten;* the remaining five feet comprised reddish sands and gravels.

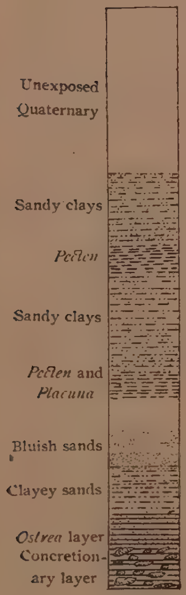
Dip of Coralline bed. About an eighth of a mile south of the northern end of Aspalaga Bluff, a small ravine enters the river valley. This ravine is the second passed in traversing the distance indicated. Up the ravine, the coralline (*Madrepora*) bed is but 15 feet above the level of the base assumed in the last section, instead of 25 feet as at Aspalaga Bluff, showing a southward dip of 10 feet to an eighth of a mile. Farther up the ravine, along the right hand fork, at a height of 135 feet above the same datum plane, the greenish-white, clayey limestone was found, containing *Placuna*, *Pecten* and two species of *Ostrea*, a large and a plicate form. The fossils range through 124 to 138 feet approximately. The same bed occurs at Aspalaga Bluff at a height of about 145 feet.

Section at Camp Scott. A mile or more above Ocheesee Landing, but on the eastern shore, a section was leveled by Mr. Pacheco. The total height of the bluff at this point was found to be 95 feet. Of this distance, the lower 75 feet and the upper 10 feet were unexposed. A fossiliferous, sandy layer with *Pecten* and *Placuna* was noted, extending from 75 to 78 feet, and an *Ostrea* bed from 81 to 83 feet, being separated from the *Pecten* bed by the hard limestone which forms the cap rock of the embankment. Above the *Ostrea* bed are red sands.

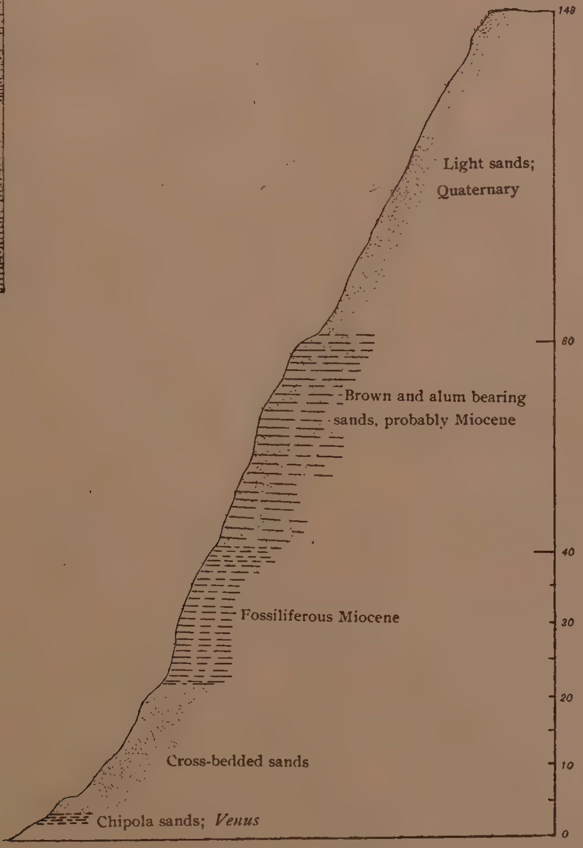


SECTION AT CAMP SCOTT.

Section at Rock Bluff (*see page 57*). A section was taken by Prof. Harris at Rock Bluff, a short distance south of Camp Scott. The total height of the bluff was found to be 90 feet above water level. The section shows the contact of a concretionary layer of



SECTION AT ROCK BLUFF.
(Scale: 1 inch = 20 feet).



SECTION AT ALUM BLUFF.

the Chattahoochee limestone and the overlying sandy clays (Aspalaga clays).

In the clays, at a height of about 30 feet, the base of a *Pecten* and *Placuna* bed was observed, and, separated from this by sandy clays, another *Pecten* bed was found at a height of about 50 feet.

Average dip of the Pecten and Placuna layer. If we suppose the layer containing *Pecten* and *Placuna* to be the same at Aspalaga, Camp Scott and Rock Bluff, we find a dip of 118 feet during the five miles between Aspalaga and Rock Bluff, or an average descent, southward, of 23 feet in a mile. That this dip is steeper toward the north is shown by the following rate of slope:

Aspalaga to the ravine,	⅛ mile,	10 feet, or	80 feet per mile.
Aspalaga to Camp Scott,	2 miles,	70 " "	35 " " "
Camp Scott to Rock Bluff,	3 "	48 " "	16 " " ".

The section of the bluff corresponds nearly with one made by Dr. Dall.* In the latter, however, a somewhat greater thickness is assigned to the limestones and clays.

Section at Alum Bluff (*see page 57*). At Alum Bluff, 3 miles below Rock Bluff, a section was also made. The total height of the bluff above water level at the time of sectioning was found to be 148 feet. The Chattahoochee limestone is no longer visible, and the fossiliferous Chipola sands, obscured in part by a talus, are found a few feet above the river. These sands are overlaid by some 19 feet of cross-bedded sands, constituting the Alum Bluff transitional beds, and underlying the fossiliferous Chesapeake Miocene. The section, in general, agrees with that of Dr. Dall.†

The Chipola marl. The Chipola marl is a compact mixture of broken shells, sand and clay. At Alum Bluff, the color of this deposit is dark red, owing to the presence of iron peroxide, but usually, at other localities, it is light yellow.

Chipolan species from Alum Bluff. The following species‡ have been identified in the material collected, under the direction of Prof. Harris, from the Chipola marls at Alum Bluff:

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* *Bull. Geol. Soc. Amer.*, vol. 5, 1895, p. 156.

† *Ibid.*, p. 157.

‡ For original descriptions and references, see Dall, *Trans. Wag. Free Inst. Sci.*, vol. 3, pts. 1-6.

+*Haminea pomphalyx* Dall.*
Dolabella Aldrichi Dall.
Terebra (*Acus*) *dislocata* (?) Say.
Drillia ostrearum Stearns.†
Clava chipolana Dall.
+*Olivella*.
+*Marginella*.
Turbinella chipolana Dall.
Fulgur spiniger Con.
Melongena sculpturata Dall, var.
Cypræa Willcoxi Dall.
Orthaulax Gabbi Dall.
Cerithium Burnsii Dall.
Turritella subgrundifera Dall.
" *terebriformis* (Con.) Dall.
Natica (*Cryptonatica*) *floridana* Dall.
Dentalium cardinense Con.
Ostrea sellæformis Con. var. *rugifera* Dall.
Pteria (*argentea* var. ?) *chipolana* Dall.
Modiolus cf. young of *curtulus* Dall.
Scapharca (*Anadara*) *campsa* Dall.
" *staminata* Dall.
Nucula chipolana Dall.
Carditamera recta Con., var. ?
Crassatellites densus (?) Dall.
Cardium (*Trigonicardia*) *alicula* Dall.
" *chipolanum* Dall.
Venus Burnsii Dall.
" *Langdoni* Dall.
Donax cf. *chipolanum*, var. *curtula* Dall.
Tellina chipolana Dall.
" (*Merisca*) *hypolispi* Dall.

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* Species marked (+) are identical with species in the Smithsonian collection awaiting description by Dr. Dall.

† *D. Ostrearum* Stearns, *Proc. Boston Soc. Nat. Hist.*, XV, p. 22, 1872.

The Chipola marls are also exposed at Bailey's Ferry, on the Chipola River, several miles west of Alum Bluff.

At McClellan's marl bed, Bailey's Ferry, Dr. Dall* observed the Chipola marl varying in depth from seven to twelve feet, resting on the Chattahoochee limestone at the water's edge.

Chipolan species from Bailey's Ferry. The marl at Bailey's Ferry contains a very rich fauna. Among the species, collected for the University at this locality, are the following:

Nautilus (fragments).
Vaginella chipolana Dall.
+ *Tornatina.*
Terebra (*Acus*) *dislocata* Say.
Atys œdemata Dall.
Conus planiceps Heil.
+ “ (3 species).
Pleurotoma albida Perry.
Drillia lunata Lea.
“ *ostrearum* Stearns.
“ (*lissotropis* var. ?) *perpolita* Dall.
+ “
Clava chipolana Dall.
+ *Cythara.*
Cancellaria conradium Dall.
“
Oliva litterata Lam.
Olivella mutica Say.
+ *Marginella* (4 species).
+ “ (*Persicula*).
Lyria.
Mitra carolinensis Con.
+ “ (2 species).
Conomitra staminea Con.
Latirus rugatus Dall.
Turbinella, young of *chipolana* (?).
“ , like *ovoidea* Gabb.

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* *Bull. Geol. Soc. Amer.*, vol. 5, p. 159.

Vasum haitense Sow. var. *egonatum* Dall.
" cf. *subcapitellum* Heil.
Fulgur spiniger Con.
" *pyrum Dillwyn*, var. *incile* Con.
" *spiniger*, var. *spiniger* Con.
+*Phos.*
+*Nassa.*
+*Astyris.*
+*Strombina.*
Typhis linguiferus Dall.
Murex mississippiensis Con.
Coralliophila magna Dall.
Pyrula papyratia Say.
Erato near *lævis.*
Strombus Aldrichi Dall.
Orthaulax Gabbi Dall.
Cerithium Burnsii Dall.
Bittium (*Styliferina*) *boiplex* Dall.
" *chipolanum* Dall.
" ", var. *Burnsii* Dall.
" " Dall var.
" *Cossmannii* Dall.
" *permutabile* Dall.
" " " var.
Vermetus (*Petaloconchus*) *varians* d'Orb.
Serpulorbis ballistæ Dall.
" *decussata* Gmelin.
Turritella subgrundifera Dall.
" *terebriformis* (Con.) Dall.
Alaba chipolana Dall.
Rissoina chipolana Dall.
" *decussata* Montagu.
Almathea Willcoxi Dall.
Crucibulum auricula Gmelin, var. *chipolanum* Dall.
Crepidula plana Say.
Calyptræa centralis Con.
" *trochiformis* Lam.

Xenophora conchyliophora Born.
“ (*Turgurium*).
Natica (*Cryptonatica*) *floridana* Dall.
Ampullina amphora Heil.
“ “ (?) Heil.
Sigaretus chipolanus Dall.
+*Scala*.
+*Eulima*.
Astralium (*Lithopoma*) *chipolanum* Dall.
“ cf. sp. indet. Dall.
Chlorostoma (*exoletum* var. ?) *limatum* Dall.
Calliostoma (*Eutrochus*) *ceramicum* Dall.
“ *exile* Dall.
“ *grammaticum* Dall.
Fissuridea chipolana Dall.
Dentalium disparile d'Orb.
Ostrea haitensis Sow.
“ *trigonalis* Con.
Anomia microgrammata Dall.
Spondylus bostrychites Guppy, var. *chipolanus* (?) Dall.
Lima tampaensis Dall.
Pecten (*Chlamys*) *alumensis* Dall.
“ (*Aequipecten*) *chipolanus* Dall.
“ *condylomatus* Dall.
“ (2 species indet.).
Pteria argentea Con. var. *chipolana* Dall.
Mytilus, young specimen.
Lithodomus nuda Dall.
Modiolaria cf. sp. indet. Dall.
Arca (*Scapharca*) *hypomela* Dall.
“ *paratina* (?) Dall.
Barbatia (*Fossularca*) *Adamsi* (Shuttleworth) Smith.
“ *irregularis* Dall.
“ *marylandica* Con.
Scapharca hypomela Dall.
“ *staminata* Dall.
Pectunculus subovata Say, var. *plagia* Dall.

Nucula chipolana Dall.
Leda linifera Con., var. *chipolana* Dall.
Yoldia frater Dall.
Cardita (*Carditamera*) *recta* Con. var. (?).
Crassinella triangula Dall.
Crassatellites densus Dall.
Cardium (*Papyridea*) *bulbosum* Dall.
" *chipolanum* Dall.
" (2 species indet.).
+*Chama* (sp. indet.).
Venus Burnsii Dall.
" *Langdoni* Dall.
+ "
Donax cf. *chipolanum*, var. *curtula* Dall.
" var. of *chipolana* (?).
Siliqua subæqualis Gabb.
Solen cf. *amphistemma* Dall, (fragment).
Mactra chipolana Dall.
Spisula (*Hemimactra*) *dodona* Dall.
Corbula chipolana Dall.
" *heterogenea* (?) Guppy.
Panopæa Whitfieldi Dall.
Gastrochæna ovata Sow., var. *rotunda* Dall.
Miltha (sp. indet.).
Aligena pustulosa Dall.
Tellina (*Angulus*) *acosmita* Dall.
" cf. *flexuosa* Say.
Syndosmya triangulata Dall.
The locality of the following species is doubtful:
+*Drillia*.
Strombina eugrammata Dall, (ms.).
Murex mississippiensis Con.

The Alum Bluff beds. The Alum Bluff bed, so named by Dr. Dall in 1891, consist of light colored sands, cross-bedded, especially a few feet above the base. A number of Chipolan species have been reported from the lower part of the deposit. In the sands are occasional clayey layers, which, in the lower part of the deposit, contain fragments of palmetto and some dicotyledonous leaves, especially those of the willow. In the upper portion, the deposit appears to be unfossiliferous. Dr. Dall considers the Alum Bluff beds as a continuation* of the clayey sands (Aspalaga clays) at Rock Bluff and Aspalaga.

The Oak Grove sands. At Oak Grove, on the Yellow River, is a ledge of fine greyish sand, containing fauna of a transitional character. It contains some species not found in the Chipola marl, and has been correlated with the Alum Bluff beds by Dr. Dall.†

Species from the Oak Grove sands. Among the species collected at Oak Grove are:

Terebra dislocata Say, var. *indenta* Con.
Conus chipolanus Dall.
" *planiceps* Heil.
+ "
Pleurotoma albida Perry, (*cochlearis* Con.).
" *boadicea* (?) Dall.
Drillia ostrearum Stearns.
Cancellaria Conradiana Dall.
" (young).
Oliva litterata Lam.
Turbinella Wilsoni Con.
Fulgur spiniger Con.
" " ", var. *Burnsii* Dall.
Pseudoneptunea near *multangula* Ph.
+*Nassa.*
+*Coralliophila.*
Strombus chipolanus Dall.
Bittium (*Styliferina*) *boiplex* Dall.
" *Cossmanni* Dall.
Vermetus varians d'Orb.
Serpulorbis granifera Say.
Turritella alcida Dall.
" *subgrundifera* Dall.

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* *Ibid.*, p. 166.
† *Ibid.*, p. 166.

Turritella terebriformis Con.
Solarium (sp. indet.).
Crucibulum auricula Gmelin, var. *chipolanum* Dall.
Crepidula plana Say.
Calyptræa centralis Con.
Natica (*Cryptonatica*) *floridana* Dall.
Ampullina amphora Heil.
Sigaretus chipolanus Dall.
  “ (*Eunaticina*) *Conradii* Dall.
+*Neritina.*
Calliostoma (*Eutrochus*) *ceramicum* (?) Dall, (young).
Ostrea trigonalis Con.
Anomia floridana Dall.
Spondylus bostrychites Guppy, var. *chipolanus* (?) Dall.
Pecten Madisonius Say, var. *Sayanus* Dall.
Pinna quadrata (?) Dall, (fragment).
Modiolus curtulus (?) Dall, (young).
Arca (*Scapharca*) *dodona* Dall.
  “ “ *santarosana* Dall.
Pectunculus subovata Say, var. *plagia* Dall.
Trinacria Meekii Dall.
Nucula sinaria Dall.
Yoldia frater Dall.
Crassatellites densus Dall.
Montacuta actinophora Dall.
Aligena lineata Dall.
Sportella lioconcha Dall.
Cardium (*Trigonicardia*) *apeteticum* Dall.
  “ *taphrium* Dall.
Venus Burnsii Dall.
Diplodonta radiata Dall.
Corbula radiatula Dall.
  “ *seminella* Dall.
Panopæa Whitfieldi Dall.
Gastrochæna (sp. indet.).
Lucina plesiolopha Dall.
Tellina (*Angulus*) *acalypta* Dall.

Tellina dodona Dall.
" (*Eurytellina*) *roburina* Dall.
Macoma tracta Dall.
+*Pandora*.

The following new species are in the Museum of Paleontology of Cornell University and not reported from the Smithsonian.

FASCIOLARIA Lamarck

Fasciolaria Ramondi sp. nov., Pl. 28, fig. 1

Shell of medium size, rather thin, eight-whorled. Nucleus small, smooth. Succeeding whorls with transverse peripheral ribs varying in number from eight to eleven. Ribs slightly less marked on the terminal than on the three preceding whorls. Entire surface covered with fine, transverse lines. Incremental lines irregular. Suture distinct on the later whorls, which are flattened beneath it. Spiral sculpture of threads, usually alternating in strength, and covering the entire surface. Canal one-fourth the entire length of the shell. Aperture elliptical. Callous thin. Plaits on columella well marked within. Outer lip thin, crenulated where perfect, compressed near the suture. Internal liræ of unequal lengths, usually not extending to the margin of the lip. Lenghth of shell, 70 mm., width, 30 mm. Length of canal and aperture, 40 mm.

This species resembles closely *Fasciolaria intermedia* Sow., from Santo Domingo, but the latter species is larger, much more solid, and lacks the fine transverse markings of the Chipolan shell.

Named in honor of M. G. Ramond of the Jardin des Plantes, Paris.

Locality.—Upper Oligocene of the Chipola River at Bailey's Ferry.

PYRAZISINUS Heilprin

Pyrazisinus Harrisi sp. nov., Pl. 28, figs. 2, 2a

Shell very solid, tapering rapidly, twelve-whorled. Whorls (except the terminal) with four equi-distant, raised spiral bands, and about 27 transverse ribs. In crossing these the bands are raised so as to appear as nodules. Terminal whorl with ten additional spiral bands, but as the transverse ribs become obsolete over the lower half, there are but four rows of nodules as with the the other whorls. On all except the two earlier whorls is a prominent, rounded varix (marking a period of retarded growth), over which the spiral bands are carried, but the transverse ribs are absent. Outer lip spreading; border much thickened within, in older specimens, but crenulated in younger. Sinus of varying depth. In many specimens the basal border of the outer lip extends to the columella and encloses a rounded aperture. Length of shell, 60 mm., width, 24 mm.

This species resembles both *Pyrazisinus campanulatus*, of the Orthaulax bed, and *Cerithium corrugatum*, from the Aquitanian of the Bordelais. It differs chiefly in its more prominent sculpture from *P. campanulatus*, and in its greater size and proportionately fewer whorls from *C. corrugatum*, which is, however, unquestionably its European analogue.

Locality.—Upper Oligocene of the Chipola River at Bailey's Ferry.

Georgia.

The Shell Bluff group—Eocene. Ruffin,* in 1843, described the bed characterized by *Ostrea Georgiana* at Shell Bluff, on the Savannah River, as resting upon the Jacksonian ('Great Carolinian' bed). This position would make the *Ostrea* layer either Jacksonian, or Vicksburgian.

Lyell,† however, in 1845, obtained typical Claiborne fossils from Shell Bluff, but there was some doubt whether they had been collected from the oyster layer.

In 1865, Conrad‡ referred the bed to the oyster layer at the base of the Vicksburg Bluff, and proposed the name Shell Bluff group for the formation. Hilgard,[*] during the same year, adopted Conrad's correlation.

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* *Report Agri. Survey S. Car.*, 1843, pp. 22-3, 34.

† *Quart. Jour. Geol. Soc.*, 1, 1845, p. 437.

‡ *Amer. Jour. Sci.*, 2nd ser., vol. 41, 1866, p. 96.

In 1895, Dr. Dall[†] placed the Shell Bluff group among the transitional beds overlying the Vicksburgian stage. During the same year, however, typical Eocene fossils were collected by Prof. Harris from the *Ostrea* bed. Several years later, Mr. Vaughan published a note to the effect that he had also obtained Eocene shells from this locality. The position of the Shell Bluff group in the Eocene was thus unquestionably established.

Vicksburg limestone. Vicksburg or Orbitoibes limestone, merging at the base into Jackson, from which it is with difficulty separable, extends as country rock over a much wider area in Georgia than Dr. Spencer[‡] has assigned to it. As indicated on the map, it forms a broad belt running northeast and southwest across the state.

Remnant of Vicksburg limestone at Rich Hill. An interesting trace of its former northward extension was found by Prof. Harris, at Rich Hill, about 12 miles north of Fort Valley, and six miles east of Roberta. This remnant shows a regular *mauvaise-terre* structure. The beds containing fossils are on a hillside. The uppermost layers are reddish sands. These are followed by Vicksburg limestone with *Pecten*, *Scutella* and *Bryozoa* in abundance. Below are whitish, or bluish white, sands and clays. No sections were made, but it is estimated that about 100 feet of sands are exposed. This isolated remnant has, for some reason, resisted the erosion that has removed the rest of the limestone from the valley between Perry and Knoxville.

Time-interval between Vicksburg and Chattahoochee series. At Baindridge, Blue Springs and Wiley's Landing, on the Flint River, the Vicksburg is overlaid by beds of the Chattahoochee series. Prof. Pumpelly[||] has noted near Bainbridge, indications of a time-interval between these limestone series. The evidences are, the presence, at the base of the Çhattahoochee, of a conglomerate, usually formed of rolled limestone pebbles not distinguishable lithologically from the Vicksburg; the irregular surface between the Vicksburg and Chattahoochee series, and the presence of masses of chalcedonized corals between the series, which indicates a period of submergence.

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[*] *Ibid.*, vol. 42, pp. 68-70.

[†] *Correlation Table*, 1895, p. 341.

[‡] *Geol. Survey of Georgia*, First Rep., 1800-1.

[||] *Amer. Jour. Sci.*, 3rd ser., vol. 46, p. 445-7.

Chattahoochee, Chipola and Alum Bluff beds. The red clay hills of the plateau region of southeastern Georgia have been shown by Dr. Pumpelly* to be formed of Chattahoochee at the base, overlaid by Chipola, which is, in turn, followed by Alum Bluff sands. These are doubtless continuations of the Florida beds.

Altamaha grits. On the Ocmulgee River are beds which correspond lithologically and faunally with the Hawthorne beds of central Florida. These beds were first described by R. H. Loughridge† as resembling the Grand Gulf sandstone. Dr. Dall‡ later named them the 'Altamaha grits.' The grits are developed in Irwin, Dodge, Ware, Tatnall and other counties. The grits represent a perizonal deposit formed under the same conditions as the Grand Gulf sandstones, and are, chronologically, nearly equivalent to the Hawthorne beds of Florida.

Alabama.

The White limestone. The Vicksburg limestone in Alabama, as in Georgia, is underlaid by Jackson, from which it can be distinguished only by the fauna. The two together form the White limestone that Tuomey|| described, in 1850, from exposures on the Alabama River. This is identical with the White limestone of St. Stephens on the Tombigbee. The latter was referred to in 1846 by Conrad§ as probably of the same age as the Vicksburg.

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* *Ibid.*, pp. 445-6.

† *10th Census*, vol.6, pt. 2, pp. 15-6.

‡ *Bull. U. S. Geol. Survey*, No. 84, p. 81.

|| *First Biennial Rep., Geol. of Ala.*, 1850, p. 152.

§ *Amer. Jour. Sci.*, 2nd ser., vol. 41, 1866, p. 96.

Prof. Winchell,† in 1856, discriminated between the upper and lower beds of the White limestone, noting that *Orbitoides mantelli* is limited to the upper part of the formation.

Salt Mountain limestone. Messrs. E. A. Smith, Langdon and Johnson,* in 1894, found these divisions of the limestone present throughout its distribution in the state. At one locality, Salt Mountain, Clarke County, a third division was observed. This overlies the others, and is composed of hard limestone, characterized by corals and echinoderms. It attains a depth of 150 feet. The authors are inclined to think that it is a continuation of the Vicksburg series which it overlies.

The Vicksburg limestone. The Vicksburg division is a soft limestone, 140-150 feet thick, which hardens on exposure to the air. It is characterized by, and in layers composed of, the shells of *Orbitoides mantelli.*

Jackson limestone. The Jackson division is a more argillaceous limestone, about 50 feet thick, and is characterized by bones *Zeuglodon.*

Grand Gulf series. The Grand Gulf sandstones reach their eastern limit in south central Alabama. Near Oak Grove, Florida, the typical sandstone beds pass beneath the Oak Grove sands, indicating that the sandstone is approximately of the same age as the Chattahoochee.

In Alabama the typical sandstone is rare. The series usually consists of clayey sands, or joint clays of a bluish, pink, purple, grey or creamy white color.

Chipolan species in Grand Gulf sands at Roberts. At Lovelace's Mill, near Roberts, a black sand, three or four feet in depth, was observed by Mr. Johnson. This was found to contain *Cardium chipolanum* and species of *Cardita*, *Lucina*, *Macoma*, *Arca*, *Pectunculus* and *Crassatella.* Dr. Dall correlates the bed with the Chipola division.

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* *Proc. Amer. Assoc.*, 1856, pt. 2, p. 85.

† *Rep. Coastal Plain of Alabama*, 1894.

Mississippi.

Vicksburg limestone. The Vicksburg limestone extends across Mississippi, forming as in Alabama, a narrow belt of 20 or 25 miles in width. In 1846, Conrad[*] noted the peculiar character of the fauna of this limestone. He writes, “The formation marks a distinct era in the American Tertiary system, intermediate to the Eocene and Miocene, but more nearly allied to the former, and perhaps it will be proper to class it as a subdivision of the Eocene.......A few of these shells have a striking resemblance to species from Dax, Grignon and Bordeaux, and I believe that the Vicksburg Tertiary will prove to have been deposited in an era more nearly allied in age to that of those localities than to the Eocene of Paris or London.”

The typical Vicksburg beds are formed of crystalline limestones and marls.

The Red Bluff beds. At Red Bluff, in Wayne County, is a ferruginous rock, described by Dr. Hilgard[†] as the Red Bluff beds. These were considered by him as possibly equivalent to the Shell Bluff beds which were referred then to the Vicksburg. The Red Bluff beds are now considered to be hardly separable, faunally, from the Vicksburg of which they represent a lower phase, having more species in common with the Jackson beds.

Section at Mint Spring Bayou. A section of the Vicksburg limestone was made by Mr. Veatch, in 1900, along the course of Mint Spring Bayou, a small creek in the outskirts of Vicksburg. The strata are given in descending geological order.

Loess and Orange sand.	1. Yellow, fossiliferous loess. *Helix* and loess *Kindchen*,	75 feet.
	2. Orange sand,	40 "
Vicksburg limestone.	1. *Arca* bed. A highly fossiliferous, blue and red, ferruginous marl, very glauconitic,	8 "
	2. Unexposed,	1 foot.

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[*] *Amer. Jour. Sci.*, 2nd ser., vol. 2, 1846, p. 124.

[†] *Geol. and Agri. of Miss.*, 1860, pp. 135-6.

3. Hard, drab, fossiliferous limestone, glauconitic; forms the cap rock of the fourth falls,	6 inches.
4. Soft, blue, glauconitic marl,	8½ feet.
5. Indurated, fossiliferous, greyish marl, making a secondary cap,	1 foot.
6. Soft, yellow, fossiliferous marl, undermined at base of falls,	4 feet.
7. Slope between falls, unexposed,	4 "
8. Indurated grey marl with few fossils. Forms cap of third falls,	2 "
9. Soft, grey marl,	3 "
10. Grey sandstone,	1 foot.
11. Slope between falls, unexposed,	3 feet.
12. Hard, grey limestone with *Crassatella* and *Cardium*. Upper six inches filled with *Pecten*. Forms cap of second falls,	23 "
13. Drab colored marl. *Cytherea bed*,	4 "
14. Dark, bluish-black, laminated, somewhat micaceous, lignitic clay,	9 "
15. Slope between falls, unexposed,	6 "
16. Same as 14, with a few faint casts,	7 "
To water level of Centennial Lake,	200 "

A photograph, taken by Prof. Harris, of the falls is shown as the frontispiece. This represents typical Vicksburg limestone. The cap rock is the hard grey limestone with *Crassatella*, *Cardium* and *Pecten* (12). Beneath is the softer, drab colored marl with *Cytherea* (13), which is being undermined by erosion.

Species from Vicksburg. The material collected from the fossiliferous beds in Mint Spring Bayou and from an outcrop of the *Arca* bed on the Cemetery road contains the following species:*

Terebra divisurum Con.,	Arca bed.
" *tantula* Con.,	" "

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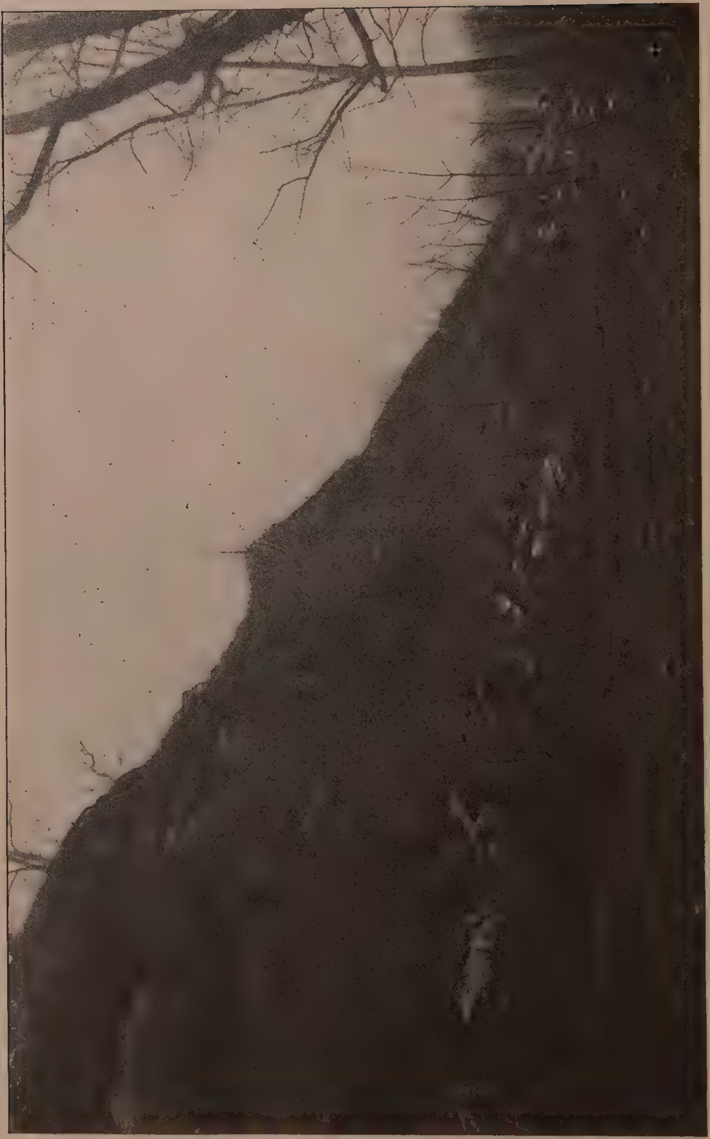
* The original descriptions of Conrad's Vicksburg species are chiefly in the *Proc. Acad. Nat. Sci.*, Phila., 1847; see also *Journal*, same Acad., 2nd ser., vol. 1, 1848.

Conus alveatus Con.,	Arca bed, Cemetery road.
Pleurotoma abundans Con.,	Cemetery road.
“ “ “	Arca bed.
“ *albida* Perry,	“ “
“ *cristata* Con.,	Arca bed, Cemetery road.
“ *decliva* Con.,	Vicksburg.
“ *servata* Con.,	Arca bed.
“ *tenella* Con.,	“ “
“ “ “	Cytherea bed.
Cancellaria funerata Con.,	Arca bed.
“ *mississippiensis* Con.,	Arca bed, Cemetery road.
Oliva mississippiensis Con.,	“ “ “ “
Fulgoraria mississippiensis Con.,	Arca bed.
Caricella demissa Con.	Arca bed, Cemetery road.
Mitra mississipiensis Con.,	Cytherea bed.
“ “ “	Mint Spring Bayou.
Clavella, sp. indet.,	Cytherea bed.
Turbinella protracta Con.,	Arca bed.
“ *Wilsoni* Con.,	Arca bed, Cemetery road.
Buccinum mississippiensis Con.,	Mint Spring Bayou.
“ “ “	Arca bed, Cemetery road.
Murex mississippiensis Con.,	Mint Spring Bayou.
“ “ “	Cytherea bed.
“ “ “	Arca bed.
Typhis curvirostratus Con.,	“ “
“ “ “	Mint Spring Bayou.
Triton crassidens Con. (fragment),	Arca bed.
“ “ “	Mint Spring Bayou.
“ “ “	Arca bed, Cemetery road.
Cassis cælatura Con.,	Cemetery road?
Cassidaria lintea Con.,	Arca bed.
Pyrula mississippiensis Con.,	“ “
“ “ “	Cytherea bed.
Solarium triliratum Con.,	Arca bed.
“ “ “	Mint Spring Bayou.
Capulus americanus Con.,	Arca bed.
Calyptræa trochiformis Con.,	Mint Spring Bayou.
Narica mississippiensis Con.,	Arca bed, Cemetery road.
Natica mississippiensis Con.,	Mint Spring Bayou.
“ *vicksburgensis* Con.,	Vicksburg.
Sigaretus misssissippiensis Con.,	Mint Spring Bayou.
“ “ “	Arca bed, Cemetery road.
Scalaria trigintanaria Con.,	Arca bed.
Dentalium mississippiensis Con.,	“ “

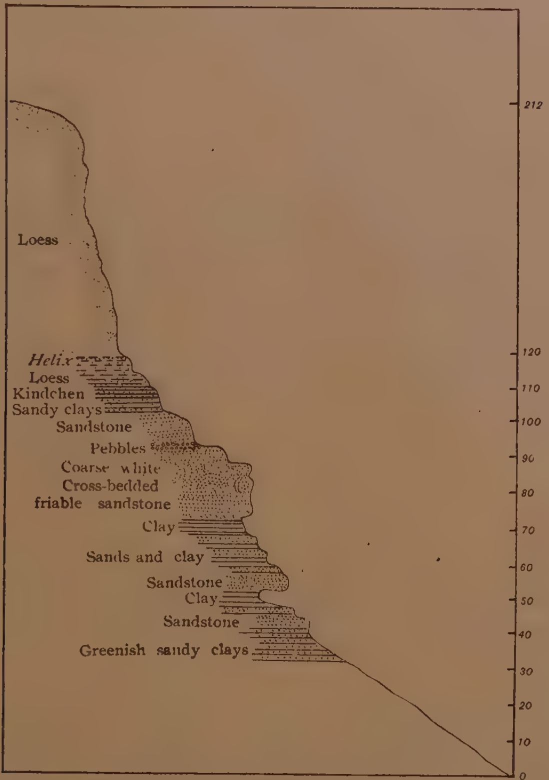
Ostrea vicksburgensis Con.,	Cemetery road.
Pecten Poulsoni Morton,	Arca bed, Cemetery road.
" " "	Mint Spring Bayou.
" " "	Cytherea bed.
Pinna argentea Con.,	Mint Spring Bayou.
Arca mississippiensis Con.,	Arca bed.
Byssoarca mississippiensis Con.,	Arca bed, Cemetery road.
" " "	Cytherea bed.
Pectunculus arctatus (?) Con.,	Arca bed.
" *mississippiensis* Con.,	Mint Spring Bayou.
Nucula sericea Con.,	Arca bed.
" " (?) (young) Con.,	Mint Spring Bayou.
" *vicksburgensis* Con.,	Arca bed.
Cardium diversum Con.,	Arca bed, Cemetery road.
" " "	Cytherea bed.
" *glebosum* Con.,	" "
Crassatella mississippiensis Con.,	Mint Spring Bayou.
" " "	Arca bed.
Cytherea astartiformis (?) Con.,	Mint Spring Bayou.
" *imitabilis* Con.,	Cytherea bed.
" " "	Mint Spring Bayou.
" " "	Arca bed, Cemetery road.
" *mississippiensis* Con.,	Mint Spring Bayou.
" *sobrina* Con.,	Arca bed.
" " "	Cytherea bed.
" " "	Mint Spring Bayou.
Donax funerata Con.,	Arca bed.
" " (?) Con.,	Mint Spring Bayou.
Mactra funerata Con.,	Vicksburg.
Corbula alta Con.,	Cytherea bed.
" *engonata* Con.,	Mint Spring Bayou.
" " "	Cemetery road.
" , sp. indet.,	Arca bed, Cemetery road.
Panopæa oblongata Con.,	" " " "
Lucina, sp. indet.,	Arca bed.
Tellina lintea Con.,	" "
" *perovata* Con.,	" "
" *vicksburgensis* Con.,	" "
Madrepora mississippiensis Con.,	" "
Orbitoides mantelli Morton,	Cytherea bed.

Grand Gulf sandstone. South of the Vicksburg belt are the Grand Gulf sandstones. These occupy a much wider surface area than the Vicksberg which they overlie, and attain a depth of about



THE BLUFF AT GRAND GULF (see page 75).

150 feet. The sandstones were first named by Wailes[*] from the bluff at Grand Gulf, of which a photograph is shown on the opposite page; where they are typical. Later they were described by Dr. Hilgard[†] as composed of coarse grains of pellucid quartz imbedded in a mass of opaque white silex. The formation contains gypsum and magnesium salts. The Grand Gulf sandstones are chiefly exposed along the Pearl River and tributaries of the Mississippi. Elsewhere they are likely to be obscured with Lafayette sands.



SECTION AT GRAND GULF.

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[*] *Agri. and Geol. of Miss.*, 1st rep., 1854, p. 216.

[†] *Geol. of Miss.*, 1860.

Section at Grand Gulf (see page 75). A section at Grand Gulf, about half a mile above the town, was made by Prof. Harris in 1902. The most striking feature is the occurrence of a bed of pebbles above the coarse white sandstone. These mark the upper limit of the Grand Gulf series. The sandstone which occurs above the pebbles is a variable bed, poorly consolidated, and passes into sandy clays and loess. The alternation of sandy and clayey beds in the bluff is well marked by the effects of erosion.

Towards the southeastern part of the state the sandstones lose the typically arenaceous character which they exhibit at Grand Gulf, and merge into variously colored clays, often containing potash and soda. The clays are similar to those in Alabama.

Flora and fauna of Grand Gulf beds. The Grand Gulf beds in Mississippi contain abundant remains of dicotyledenous and coniferous trees and palms. The flora is richest in the upper beds of the series, at Hattiesburg, where the plant remains correspond to those of the Alum Bluff sands. Few animal remains have thus far been noted. A cast of *Unio* was found by Mr. Johnson, casts of freshwater bivalves by Mr. Meyer* and fragments of turtle by Dr. Hilgard.† The formation is thus shown to pass into freshwater beds to the westward of Alabama.

Louisiana.

The Vicksburg limestone. The Vicksburg limestone‡ appears in Louisiana only in the vicinity of Rosefield, and probably along Bayou Funne Louis. Mr. Vaughan|| has obtained typical Vicks-

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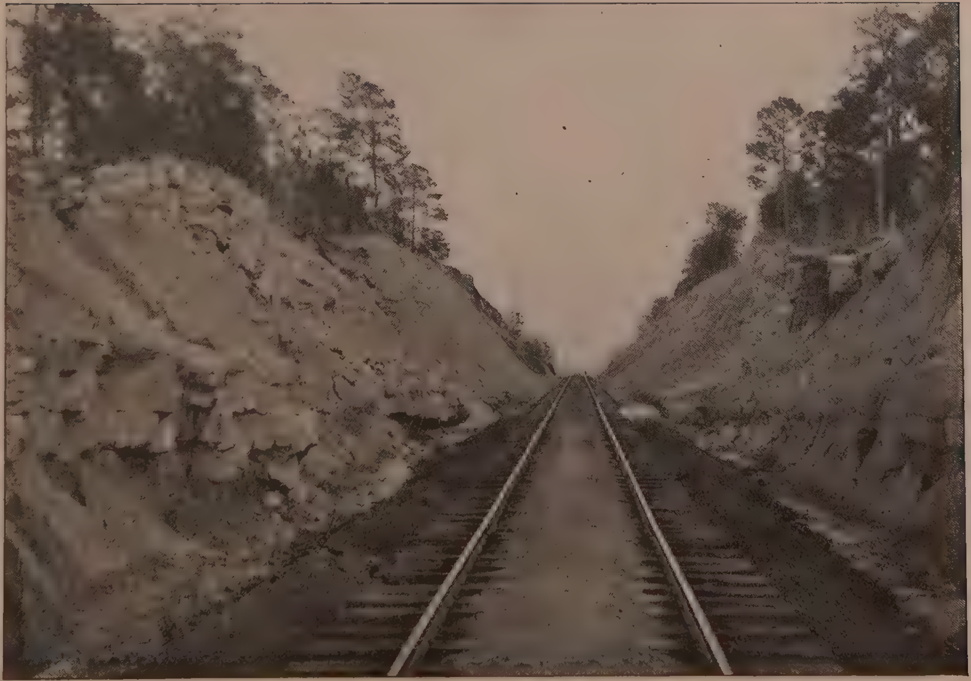
* *Amer. Jour. Sci.*, 3rd ser., vol. 32, 1886, p. 25.

† *Ibid.*, vol. 22, p. 59.

‡ Dr. Hilgard assigned a far larger area to this formation in Louisiana than recent investigation has shown it to occupy. (See Harris and Veatch, *Geol. Survey La.*, 1899, pp. 93-4). In 1869 (*Amer. Jour. Sci.*, 2nd ser., vol. 47, pp. 78-88), he refers nearly all the marine Tertiary of the state to the Vicksburg. See also the *Supplementary and Final Report of a Geol. Reconnaissance in La.*, 1883.

|| *Amer. Geol.*, vol. 15, 1895, pp. 205-229.



TYPICAL GRAND GULF SANDSTONE NEAR LENA, LOUISIANA (see page 77).

burg species from the former locality, and Dr. Hilgard[*] mentions a ledge of Vicksburg limestone with *Orbitoides*, *Arca mississippiensis* and *Pecten Poulsoni* along the Bayou. These outcrops form the western limits of the Vicksburg series.

Grand Gulf sandstones and clays. The Grand Gulf beds are interrupted by the Mississippi River and its wide alluvial plains, but they reappear at Sicily Island[†] and again near Harrisonburg. Passing thence across the state in a southwesterly and westerly direction, they enter Texas. A cut through typical Grand Gulf sandstone near Lena is shown in the photograph[‡] on the opposite page.

In the southern portion of the Grand Gulf area, the sandstones merge into variously colored clays. In this, and in other respects, these beds present a close similarity to those of the same series in Mississippi. As in that state, the rugged surface topography of the sandstone area forms a marked contrast to the level plains which are underlaid by Vicksburg and Jackson limestones.

Flora and fauna of the Grand Gulf. The Grand Gulf beds in Louisiana, as in Mississippi, contain wood of dicotyledenous trees and palms, but no animal remains have yet been reported.[||]

During the past winter, a bed containing a number of *Unionidæ* was found by Prof. Harris at Chalk Hills, two and three-quarters miles south of Rosefield in the southwestern quarter of Section 7.

Unionidæ from Grand Gulf series. The fossiliferous layer, which is but five or six inches in thickness, is interstratified with white clays. The latter are popularly called chalk, and have given rise to the name, Chalk Hills. All the specimens are in the form of casts. The matrix is a consolidated, light grey clay, very fine in texture. The casts show evidence of great pressure, which, in many cases, has resulted in their distortion. With the shells are beautifully preserved leaves of willow, birch and dicotyledonous trees, showing that land was adjacent to the shallows in which the deposition occurred. The material contains two new species of *Unio* and one of *Anodonta*.

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[*] *Amer. Jour. Sci.*; vol. 30, 1885, pp. 266-269.

[†] See Darby, *Emigrant's Guide*, 1818.

[‡] From *Geol. Survey Louisiana*, Harris and Veatch, 1899, facing p. 96.

[||] The scarcity of organic remains was explained by Dr. Hilgard, in 1871 (*Amer. Jour. Sci.*, vol. 2, p. 348), as due to the temporary conversion of the Gulf of Mexico into a dead sea. In 1874, he abandoned this explanation in favor of the theory that the organic remains had been obliterated by the oxidizing influence of ferruginous solutions percolating from above. (*Ibid.*, vol. 7, 1874, pp. 208-210).

UNIO Philipsson

Unio ? trigoniaformis sp. nov., Pl. 29, figs. 1, 2

Shell rather small, triangular, strikingly like *Trigonia* in form. Posterior end somewhat pointed, anterior rounded. Basal margin curved. Beaks large and prominent, placed at the anterior third of the shell. Valves apparently thin and light, sculptured, in the specimen described, by five, pronounced radial plications with interspaces of nearly equal width. The number and position of the plications varies in different individuals; in some they are obsolete in the anterior area, and, in general, they tend to be more marked towards the posterior area. At the ventral edge of the shell, the plications are prolonged beyond the interspaces, forming a sinuous margin. Lines of growth wavy, following the sinuosities of the base. Length of shell, 40 mm., height, 30 mm.

Portions of the casts show a punctate surface. This seems to have been caused by a foreign growth on the outer surface of the shell, forming encrustations analogous to those of *Microcoleus hyalinus* on recent species of *Unio* and *Anodonta*.

Unfortunately, no trace of teeth or of beak sculpture is to be seen.

This species is evidently not a member of the genus *Unio*, *sensu stricto* and it is only referred to that genus until more material is obtained by which the section to which it belongs can be definitely determined. That the species is a member of the *Unionidæ* can hardly be questioned when the characters of the shell and the forms with which it is associatrd are considered.

In some respects, this shell recalls the South American genus, *Castalia*.

Unio cretacollis sp. nov., Pl. 29, fig. 4

Shell of medium size, broadly elliptical, slightly winged at the dorsal margin. Posterior area marked off from the anterior by a rounded plication which passes from the beak to the posterior extremity. Beaks low, placed at the anterior sixth of the shell. Length of shell, 60 mm., height, 45 mm.

ANODONTA Lamarck

Anodonta Cornelliana sp. nov., Pl. 29, fig. 3, 5, 6, 7

Shell elongate-oval, apparently thin and light. Posterior extremity prolonged and sharply pointed, anterior rounded. Posterior area defined by a sharp carina, passing from the beak to the posterior extremity. Lines of growth delicately impressed. Beak rather prominent, placed at the anterior fifth of the shell. Beak sculpture concentric. Length of shell, 75 mm., height, 30 mm.

The Frio clays. The Frio clays have been traced by Mr. Veatch in the southwestern part of Louisiana. They overlie the Grand Gulf beds and are a continuation of the Texas formation which thins out and disappears in Louisiana.

Texas.

The Grand Gulf sandstones. The Grand Gulf sandstones continue from Louisiana into Texas, and pass through that state in a westerly and southwesterly direction, forming a belt of some 12 miles in average width.

Dr. Hilgard,* in 1871, suggested the continuation of the sandstone series from the Sabine to the Rio Grande Rivers. In 1880, this was confirmed by the observations of Mr. R. H. Loughridge,† who traced the sandstone from Trinity River to the Rio Grande by actual outcrops.

Mr. R. Penrose,‡ in 1889, named the formation the 'Fayette beds,' but regarded them as equivalent to the Grand Gulf series.

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* Miss. embayment, *Proc. Amer. Assoc. Adv. Sci.*, vol. 20, map opp. p. 222.

† *Census Report*, vol. 5, 1880, p. 679.

‡ *Rep. Geol. Gulf Tertiaries of Texas*, p. 47.

In 1895, Mr. William Kennedy* referred both the Fayette sandstones and the Frio clays to the lower Claiborne, because of the presence of *Venericardia planicosta* in the sandstones. Mr. Veatch, during the winter of 1902, has examined the sandstones and finds *Venericardia planicosta* is limited to the basal layers of the formation. These he refers to the Jackson; but the greater portion of the sandstones and the lower beds of the Frio clays he regards as Grand Gulf.

The sandstones are often cross-bedded and lenticular. Clays predominate in the upper part of the series.

Flora and fauna of Grand Gulf beds. The Grand Gulf beds contain abundant remains of palmetto, rushes, marsh grass and and other vegetation of a marshy habitat. The upper clays of the series are characterized by tree trunks which have become opalized by the infiltration of silex. There appear to be no indigenous animal remains, but a few have been reported washed in from neighboring beds.

The Frio clays. The Frio clays are a series of dark blue, red, green, brown and yellow clays, weathering to paler colors. The beds are more or less gypseous throughout. They are sometimes laminated, but usually massive. They overlie the Grand Gulf beds, and form a belt of nearly equal width. Mr. Kennedy† writes that they extend almost to the Louisiana line; but Mr. Veatch has shown that they continue for some distance into the state.

Fossiliferous bed in Frio clays near Burkville. The Frio clays have been thought to be fossiliferous only in central and western Texas, but Mr. Veatch found a fossiliferous layer near Burkville, not far from the eastern state line. The bed was about 100 feet above the base of the clays. The fossils are all in the form of casts. The matrix is a peculiar ferruginous rock, loosely consolidated and containing siliceous nodules with a geoditic structure. The fauna appears to be brackish.

Correlation of the Oligocene beds in the Southern States. A correlation of the Oligocene beds discussed in the preceding pages is given in the following table:

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* Eocene Tertiary of Texas, *Proc. Acad. Nat. Sci.*, Phila., 1895, pp. 92, 98.

† *Ibid.*, p. 94.

CORRELATION TABLE OF THE OLIGOCENE OF THE SOUTHERN STATES.

		Central Fla.	Northern Fla.	Georgia.	Alabama.	Mississippi.	Louisiana.	Texas.
OLIGOCENE.	Transitional.		Alum Bluff beds. Oak Grove sands.	Bainbridge residual beds.		Upper Grand Gulf sandstone. (Hattiesburg phase).		
	*	* * * *	* * * *	* * * *	* * * *	* * * *	* * * *	* * * *
	Upper or Chipolan Epoch.	Tampa limestone.	Chipola marl.	Bainbridge residual beds.	Grand Gulf fossiliferous sands at Roberts with *Cardium chipolanum*.			
		Orthaulax bed.	Chattahoochee clays and limestones.	Bainbridge residual beds.	Typical Grand Gulf sandstone.	Typical Grand Gulf sandstone.	Frio clays. Grand Gulf sandstone.	Frio clays. Grand Gulf sandstone.
		Hawthorne beds.		Altamaha grits.				
	*	* * * *	* * * *	* * * *	* * * *	* * * *	* * * *	* * * *
	Lower or Vicksburgian.	Ocala limestone.			Coral lim'stn. (Salt M't'n).			
		Vicksburg limestone.	Vicksburg limestone.	Vicksburg limestone.	Vicksburg limestone.	Vicksburg limestone.	Vicksburg limestone.	
						Red Bluff beds.		

PART III.

COMPARISON AND CORRELATION OF THE OLIGOCENE OF THE SOUTHERN STATES WITH THAT OF WESTERN EUROPE.

Resemblances of the European Oligocene Fauna to That of the Southern States.

Foraminifera. That foraminiferal life reached a remarkable development during the deposition of the Vicksburg limestone is established by the fact that many layers of this rock are formed almost wholly of the remains of *Orbitoides.* The wide geographical distribution of this genus, from Florida to Louisiana, contrasts with the very limited area in which the nummulites flourished at a slightly later period.

A simultaneous developement of foraminifera occurred in western Europe. In the Adour limestone, *Nummulites intermedia* and other species abound. In the Gironde valley, the *Asterias* limestone contains *Archiacina armorica* in considerable numbers, while the limestone of Rennes is characterized by this species. In Germany, foraminiferal developement in the Oligocene period was somewhat later, occurring chiefly during the deposition of the Septaria clays.

Echinodermata. The Chattahoochee beds of Georgia and northern Florida show a developement of Echinodermata as rich as that of the analogous, but somewhat earlier, fauna of the *Asterias* limestone of the Gironde.

Comparison of molluscan species. Conrad was one of the first to attempt a comparison of the Tertiary molluscan species of Europe and America. In his check list* he enumerates some five species as common to both continents. Later, in 1833,† he added eleven, but in a subsequent article,‡ he rejected all except two of these, and added several others. Ultimately all were rejected excepting those originally published.

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* Smith. Miss. Col., No. 200, 1866.

† Tert. For., p. 34.

‡ *Amer. Jour. Sci.*, 2nd ser., vol. 1, p. 219.

Dr. Lea,* in 1833, expressed a doubt whether a single American species would prove strictly analogous with a European form. Nevertheless he made several comparisons. Dr. Bronn,† in 1848, mentions a few American as synonyms of European species. Prof. Heilprin, in 1879,‡ 1884|| and 1887,§ compared a considerable number of closely allied or identical forms among the Eocene and Miocene of the two continents. Under the Oligocene, he takes up only *Ostrea Georgiana* Con., which, he suggests, may be analogous with *O. crassissima* Lmk., of Europe. As the Shell Bluff beds containing *O. Georgiana* are now referred to the Eocene, no identical forms would be left in his grouping under the Oligocene.

Dr. Otto Meyer,** in 1884, from a study of some 706 German Tertiary shells and a number of American forms, found a few identical species, which are quoted in Heilprin's article of 1887. Dr. Dall,†† in his decription of the Florida Tertiary fauna, calls attention to a number of species analogous with the European, but the majority of these are Pliocene or Post Pliocene.

Oligocene species. The identical or closely allied species in the Oligocene of the two continents are but few. Among them are the following:

TRIFORIS PERVERSUS Linné

This species is cited by Speyer (Lippe-Detmold, p. 21) from the German Oligocene, and by Benoist (Cat., p. 340) and Degrange-Touzin (Le Thil) from the Gironde valley. Dr. Dall (*Trans. Wag. Free Inst. Sci.*, iii, p. 264) regards *Cerithium modestum*, C. B. Adams (Contr. Conch., p. 117, Ap., 1850) as a variety of *Triforis perversus*, and cites this variety from the Oligocene of the Chipola beds. It is also found in the Caloosahatchie

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* Contr. to Geol., p. 19.

† Index Palæontographicus, 1848-9.

‡ *Proc. Acad. Nat. Sci.*, Phila., 1879, pp. 217-225.

|| *Jour. Acad. Nat. Sci.*, Phila., 1884, pp. 104-112.

§ Contr. Tert. Geol., 1887, pp. 83-101.

** *Proc. Acad. Nat. Sci.*, Phila., 1884.

†† *Trans. Wag. Free Inst. Sci.*, vol. 3.

Pliocene and living in shallow water from Cape Hatteras to the Antilles.

PYRAZISINUS HARRISI sp. nov.

This species from the Chipola marls, described on a preceding page, is closely allied to *Cerithium corrugatum* Basterot, from the Oligocene of the Gironde.

RISSOINA DECUSSATA Montagu

Helix decussata Montagu, Test. Brit., 1803, p. 399.

Cited by Benoist (Cat. p. 287) from the Gironde Oligocene. Dall (*Trans. Wag. Free Inst. Sci.*, iii, p. 343), Oligocene of the Chipola beds, Caloosahatchie beds, living in the Antilles and the Mediterranean.

CREPIDULA PLANA Say

Jour. Acad. Nat. Sci., Phila., ii, p. 226, 1822.

This species cannot be distinguished from *C. unguiformis* Lmk. (Dall, *loc. cit.*, p. 358). Oligocene of the Chipola marl, Miocene, Pliocene, Post-Pliocene. Recent on Atlantic coast. *C. unguiformis* Lmk. cited by Benoist (Cat. p. 275) from the Gironde Oligocene.

XENOPHORA CONCHYLIOPHORA Born

Trochus conchyliophorus Born, Mus. Caes. Ind., p. 333, 1778.

A variety of this species is found, according to Grateloup, in the Adour valley (Atlas, pl. 13, figs. 1, 2, 1840). This species is reported from the Cretaceous of Alabama and New Jersey, the Eocene of Wood's Bluff and Jackson, the Oligocene of the Orthaulax bed and the Tampa limestone, the Miocene, the Pliocene; living along the Atlantic coast from Cape Hatteras to the Antilles, and in the Gulf of Mexico.

AMPULLINA CRASSATINA (Lmk.) Desh.

Natica crassatina Deshayes, Anim. s. vert., 3, p. 58; 2, p. 171, pl. 20, figs. 1, 2.

Oligocene of the Adour, Grateloup (Atlas, pl. 6 (1), fig. 3); of the Gironde, Fallot (l'Étage Tongr. Gironde), Benoist (*Act. Soc. Lin.*, Bordeaux, 1885); of Mainz, Sandberger (Mainz Tert.,

p. 161, pl. 13, figs. 1, a, b), Lepsius (Mainz Beck); of Rennes, Vasseur (Ter. tert. de la Fr. occid,, pp. 334, 336). Tournouer (Tongr. de Rennes, p. 472); of the Paris basin, Cossmann and Lambert (Olig. d'Étampes, p. 55), Stanislaus-Meunier (Pierrefitte, p. 237). Dr. Dall (*loc. cit.*, p. 375) regards *Natica mississippiensis* Con. (*Proc. Acad. Nat. Sci.*, Phila., iii, 1847, p. 283) as a variety of the European species. *Ampullina crassatina* Lmk., var. *mississippiensis* Con. is reported from the Eocene of Alabama, and from the Oligocene beds of Red Bluff and Vicksburg, Miss. The variety is narrower and more elevated than the type (Dall).

BARBATIA ADAMSII (Shuttleworth) Smith

Arca Adamsii Smith, *Jour. Lin. Soc. Zool.*, vol. xx, p. 499, pl. 30, figs. 6, 6a, 1888.

Oligocene of the Chipola River and of Oak Grove, Florida. This species was identified by Adams with *Arca lactea* Lin. from the Aquitanian of the Bordelais (Degrange-Touzin, Le Thil). Dr. Dall (*loc. cit.*, pp. 629, 630) thinks certain minor differences sufficiently constant to distinguish the species, which are, however, unquestionably closely allied.

European Oligocene species in American Eocene and Miocene beds. It may not be without interest to note that a number of European species, or their analogues, are found in the American Eocene and Miocene beds, but have not been, as yet, reported from the Oligocene. Among these are the following:

Eocene.

TORNATELLA BELLA Conrad

Jour. Acad. Nat. Sci., Phila., 2nd ser., iv, p. 294.

According to Heilprin (Contr. Tert. Geol., p. 91), there is no difference between this Eocene species and the European *Auricula* (*Actæon*) *simulata* (*Bulla simulata*) Brander (Foss. hant., p. 29, pl. 4, fig. 61). By European authors it is usually placed in the genus *Tornatella*. Reported from European Oligocene by Nyst (Coq. et poly. foss., p. 423), De Koninck (Coq. foss. Baesele, p. 8), Koenen (*Pal.* 16, p. 121), Cossmann and Lambert (Olig. d'Étampes, p. 120).

PLEUROTOMA ACUMINATA Sowerby

Min. Conch., ii, p. 105.

European Oligocene, De Koninck (Coq. foss. Basaele, p. 24), Nyst (Coq. et poly. foss., p. 519, pl. 14, figs. 1, a, b). Eocene of Clarke County, Alabama.

PLEUROTOMA DENTICULA Basterot

Bass. Tert. du S. O. de la Fr., p. 63, pl. 3, fig. 12.

Oligocene of Germany, Koenen (Mit. Olig. N. D. *Pal.*, 16, p. 89); of the Adour, Grateloup (Atlas, pl. 20, fig. 8); of Belgium, Mourlon (Géol. de Belgique, 2, p. 196), Nyst (Coq. et poly. foss., p. 526), Van den Broeck (Feuille de Bilsen). Alabama Eocene specimens in the Nat. Hist. Museum in New York have been identified by Prof. Heilprin with this species (Contr. Geol., p. 94).

CANCELLARIA TORTIPLICA Conrad

This species is intimately allied with *Cancellaria* (*Buccinum*) *evulsa* Brander. The spire of the American species is slenderer and more elevated (Heilprin, Contr. Tert. Geol., p. 93). American Eocene.

Cancellaria evulsa is common in the Oligocene of northern Europe. It is cited by Speyer (Sollingen, p. 268), Nyst (Coq. et poly. foss., p. 477), Lepsius (Mainz Beck.), De Koninck (Coq. foss. Baesele, p. 10), Koenen (Mit. Olig. N. D. *Pal.*, 16, p. 71), Beyrich (Conch. N. D. Tert. *Zeits.*, 8, p. 556, pl. 26, figs. 2, a, b, c, 3, 4, 5).

PYRULA PENITA Conrad

Foss. Shells of Tert., p. 32.

Heilprin (Contr. Geol., p. 92) identifies this Eocene shell with *P. nexilis* Sol. *Pyrula nexilis* is reported from the German Oligocene by Beyrich (Conch. N. D. Tert. *Zeits.*, 6, p. 773, pl. 15, figs. 2, a) and by Speyer (Cassel, *Pal.*, 9, p. 187).

CERITHIUM TRILINEATUM Phil.

Enumeratio Molluscorum Siciliæ, vol. i, p. 195.

Meyer (Notes on Tert. Shells, *Proc. Acad. Nat. Sci.*, Phila., 1884, p. 105) finds this species and *Terebra constricta* H. C. Lea (*Amer. Jour. Sci.*, xi, p. 100, pl. 1, fig. 18), from the Claiborne Eocene, identical.

This European shell is reported from the German Oligocene by Speyer (*Pal.* 16, p. 211, pl. 23, figs. 9, a, b, c; pl. 24, figs. 1, a, b, and Sollingen, p. 278); from the Bordeaux beds by Degrange-Touzin (Le Thil) and Benoist (Cat. p. 336); and from the Paris basin Oligocene by Cossmann and Lambert (Olig. d'Étampes, p. 150, pl. 5, figs. 10, a, b, c).

SOLARIUM ORNATUM Lea

Contr. Geol., p. 120.

Bronn (Index Palæontographicus, 1848, p. 1153) considers this species synonymous with *S. stramineum* L. and *S. canaliculatum* Lmk. But Dall (*Trans. Wag. Free Inst. Sci.*, vol. iii, p. 324) says *ornatum* is a synonym of *canaliculatum* Con., but not of *canaliculatum* Lamarck. The American shell is found in the Alabama Eocene.

Mourlon (Géol. de la Belgique, 2, p. 196) reports *S. canaliculatum* Lmk. from the Oligocene of Belgium.

SIGARETUS CANALICULATUS Sowerby

Min. Conch., iv, p. 115, pl. 384.

Oligocene of Belgium, Nyst (Coq. et poly. foss., p. 449). Claiborne, Alabama Eocene, Conrad (Foss. Shells Tert., 2, p. 34).

OSTREA COMPRESSIROSTRA Say

Jour. Acad. Nat. Sci., Phila., iv, p. 132.

This Eocene species is found by Heilprin (Contr. Tert. Geol., p. 85) to be very close to *O. bellovacina* Lmk. The latter is cited by Nyst from the Oligocene of Belgium (Coq. et poly. foss., p. 318).

PSAMMOBIA EBOREA Conrad

Foss. Shells of Tert., 1st ed., p. 42.

According to Heilprin, this species is so close to *Solecurtus* (*Sanguinolaria*) *compressus* Sow. that, at first sight, they may be readily mistaken (Contr. Tert. Geol., p. 90). The American species is Eocene.

The foreign analogue is found in the Belgian Oligocene (Nyst, Coq. et poly. foss., p. 49).

Miocene.

SOLEN ENSIS Linn.

Heilprin (Contr. Tert. Geol., p. 99) considers that this species and *S. ensiformis* Con. (Foss. Med. Tert., p. 76, pl. 43, fig. 8), of the American Miocene, are identical. Var. *B.* Lmk. of *S. ensis* is reported by Nyst from the Belgian Oligocene (Coq. et poly. foss., p. 47).

SAXICAVA ARTICA Linn.

Syst. Nat. Ed., xii, 1767, p. 1113.

This species is found in the Oligocene of Germany, Speyer (Sollingen, p. 294, =*bicristata* Sandb.) and Koenen (Mit. Olig. N. D. *Pal.*, 16, p. 266); of Mainz, Lepsius (Mainz Beck.); and of Bordeaux, Benoist (Cat., p. 19).

It occurs in the American Miocene, Pliocene, Pleistocene, and living in temperate seas. Mayer (*Proc. Acad. Nat. Sci.*, Phila., 1884, p. 108) places *S. Jeurrensis* Desh., from the Oligocene of Étampes, and *S. bilineata* Con. as synonyms of *S. artica*.

Correlations of European Oligocene Beds with Those of the Southern States.

Conrad's correlation. Conrad, in 1866,* referred the Vicksburg limestone to the Oligocene beds of Beyrich, both series being characterized by a peculiar fauna, intermediate between Eocene and Miocene. In 1875,† Conrad states that he regards the Jackson as older Oligocene, and the Vicksburg as newer Oligocene. This confirms his earlier view, in 1846, that the faunal affinities of the Vicksburg group were stronger with the species of Dax and the Bordelais than with the Eocene species of the Paris basin.

The correlation of Conrad was, however, not generally accepted, and the Vicksburg was classed as Upper Eocene. The Chattahoochee series was placed in the Lower Miocene.

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* Check list foss. N. A., *Smith. Miss. Coll.*, No. 200.

† Geol. N. Carolina, vol. 1, 1875, Appendix A, p. 25.

Heilprin's correlation. In 1884 and 1887,* Prof. Heilprin referred the Nummulitic beds at Ocala, Florida, to the Italian, and, through the Italian, to the French Oligocene. The discovery of *Orbitoides ephippium* (*O. sella*), a Biarritz species, in the Vicksburg limestone at Loeneckers, on the Cheeshowiska River, in Florida, led Prof. Heilprin to refer the Vicksburg limestone also to the European Oligocene.

Dall's correlation. Dr. Dall, in 1892,† admitted the analogy of the Vicksburg and Ocala limestones with the European Oligocene, but strongly questioned the propriety of recognizing the American beds as constituting a distinct epoch, equivalent or analogous in value, to the Eocene, Miocene or Pliocene, Nevertheless, although Dr. Dall uses the terms Upper Eocene and Lower Miocene in reference to the Vicksburg and Chattahoochee series throughout the earlier portion of the "Tertiary Fauna of Florida,"‡ in Part 4 of the article, the term Oligocene is adopted, but without explanation. In the Correlation Table|| of 1895, Dr. Dall groups the Vicksburg, Chattahoochee and Grand Gulf series under the Oligocene, using the term as coordinate with the Eocene and Miocene. The Chattahoochee series is referred to the Aquitanian, the Shell Bluff group (of which the position is questioned) to the Tongrian, and the Vicksburg series to the Ligurian (Tongrian of Sacco). The Alum Bluff beds and Oak Grove sands are correlated, through the Deep River beds, with the Sausans (Gers) beds of France.

Summary and correlation. A comparison of the invertebrate faunas or the two continents offers but little evidence, either for or against the argument, that the Vicksburg and Chipola epochs may properly be referred to the Oligocene. Rather more European Oligocene species or their analogues occur in the American Eocene than in the so-called Oligocene beds. Some also are found in the American Miocene. Yet certain characteristic

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* Contri. to Tert. Geol.

† *Bull. U. S. Geol. Survey*, No. 84, 1892, p. 105.

‡ *Trans. Wag. Free Inst. Sci.*, vol. 3, 1890.

|| *18th Ann. Rep. U. S. Geol. Survey*, 1896, facing p. 334.

Oligocene species, or their varieties, are in the Vicksburg and Chipola beds, and as more of the Chipola species are described further similarities may be noted. This incomplete evidence, furnished by the invertebrates, is strengthened by the resemblances found by Scott and others between the vertebrate faunas of the two continents during the period.

The stratigraphic indications are also not decisive. The Paris basin Eocene (calcaire grossier) is represented by the Claiborne, and the European Miocene by the Chesapeake Miocene. Between both these equivalents are beds characterized by intermediate faunas. If the Vicksburg and Chipola beds were cut off from the Eocene and Miocene by stratigraphic breaks we should have to recognize them as corresponding to the Oligocene. But a far stronger unconformity exists between the Vicksburg and the Chattahoochee series than has yet been observed between the Vicksburg and the Eocene, or between the Alum Bluff beds and the Miocene. This would seem to indicate that the Vicksburg is really upper Eocene and the Chattahoochee lower Miocene, were it not for the very marked faunal difference, induced by change in elevation, between the Chipola beds and those of the Chesapeake Miocene. Although it is at present impossible to refer the Vicksburg and Chipola epochs to the Oligocene of Europe with absolute certainty, yet the balance of probability points in that direction.

Correlation table. A correlation table of the European and American beds which have been discussed in the preceding pages is appended.

The nomenclature of the Oligocene epochs in Europe is very variable. The system followed by the writer has been to use the term and its extension given in the region in which the deposits are most typical. Thus the Tongrian is substantially that of Dumont, the Rupelian that of Dumont as modified by Mourlon and later Belgian geologists, the Stampian that of Cossmann and Lambert, and the Aquitanian that of Mayer.

COMPARATIVE STRATIGRAPHIC TABLE OF THE OLIGOCENE OF V

		Germany.	Belgium.	Paris.	Brittany.	Gir
OLIGOCENE.	TRANSITIONAL.					
		* * * *	* * * *	* * * *	* * * *	* *
	AQUITANIAN.	Lignite of the Rhenish provinces. Marine sands of Cassel and Bunde.	Plastic clays with Aquitanian flora (?).	Beauce limestone and Montmorency millstones. Clays of Étampes.	Freshwater limestone and clays of Rennes.	Grey limes Sands o White limes
		* * * *	* * * *	* * * *	* * * *	* *
	STAMPIAN.	Stettin sands. Septaria clays of Mecklenburg and Hanover.	Septaria clays of Boom. *Leda Deshayesiana.*	Sands of Ormoy. Sands of Pierrefitte.		
		* * * *	* * * *	* * * *	* * * *	* *
	RUPELIAN.	Cassel lignite.	*Nucula* clays. Berg sands.	Sands of Morigny. Marls of Jeurre. *Ostrea* clays, *Natica crassatina.*	Limestone characterized by *Archiacina* also containing *Natica crassatina.*	Limes Bour *Ast* *Ostre*
		* * * *	* * * *	* * * *	* * * *	* *
	TONGRIAN.	Magdeburg sands.	Vieux-Joncs marls. Neerrepen sands. *Ostrea* bed.	Limestone of the Brie. Clays. Gypsum?		Limes Civr. of C Frons san

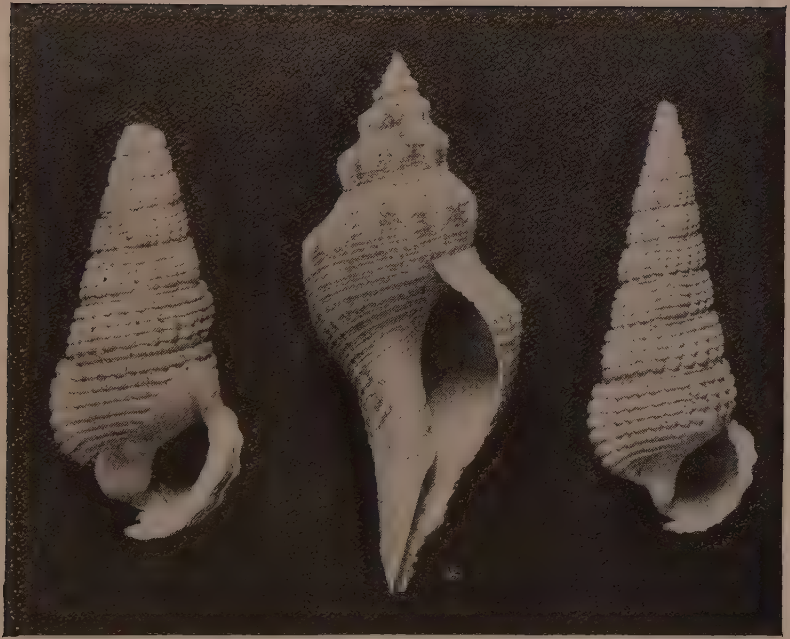
VESTERN EUROPE AND THE SOUTHERN UNITED STATES.

onde.	**Adour.**	**Mainz.**	**Languedoc and Central Plateau.**	**Southern States.**
				Alum Bluff beds. Oak Grove sands. Grand Gulf sandstone. (Hattiesburg phase).
* *	* * * *	* * * *	* * * *	* * * *
tone of Agen. tone f Bazas. : tone of Agen.	Marls of St. Paul and St. Avit.	*Corbicula* limestone. *Cerithium* limestone. Sandstone with leaf imprints.	Clays of La Limagne with *Helix Ramondi*. Blue clays with *Potamides*.	Chipola marl. Frio clays. Typical Grand Gulf sandstone. Chattahoochee clays and limestones.
* *	* * * *	* * * *	* * * *	* * * *
		Cyrena bed. Elsheim sands. Septaria clays.		
* *	* * * *	* * * *	* * * *	* * * *
tone of g with *erias*.	Limestone of the Adour with nummulites and *Natica crassatina*.	Marine sands of Alzey and Weinheim.	Limestone of Montredon.	Florida nummulitic limestone. Vicksburg *Orbitoides* limestone with *Natica crassatina* var. Red Bluff beds.
ı bed.		*Ostrea* bed.		
* *	* * * *	* * * *	* * * *	* * * *
tone of ac and astillon. ac dstone.				

Plate 28

EXPLANATION OF PLATE 28.

Fig.		Page.
Fig. 1.	*Fasciolaria Ramondi* n. sp.	66, **376**
2.	*Pyrazisinus Harrisi* n. sp.	66, **376**
2a.	“ “	



2a 1 2

Plate 29

EXPLANATION OF PLATE 29.

Page.

Fig. 1. *Unio? trigoniaformis* n. sp.......................... 78, **388**
Imprint of exterior.

2. *Unio? trigoniaformis* n. sp. Cast.

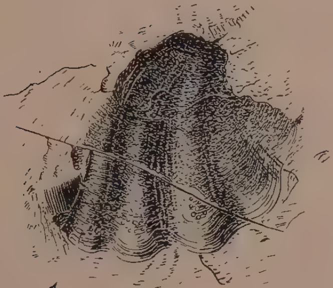
4. *Unio cretacollis* n. sp.................................... 79, **389**

3. *Anodonta Cornelliana* n. sp. Anterior part.... 79, **389**

5. Posterior of presumably the same shell.

6. Same shell (young, broken).

7. Same shell (anterior missing).



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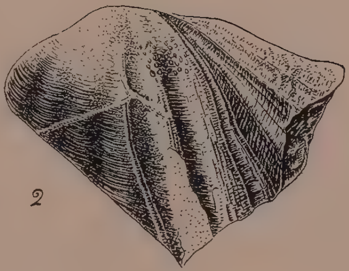

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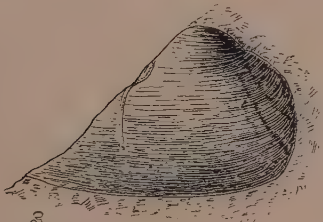

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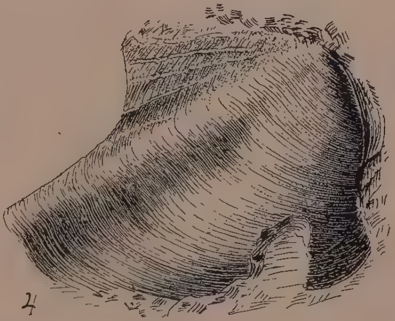

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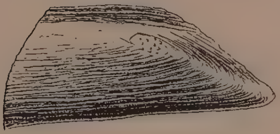

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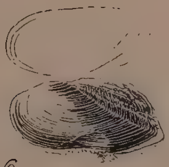

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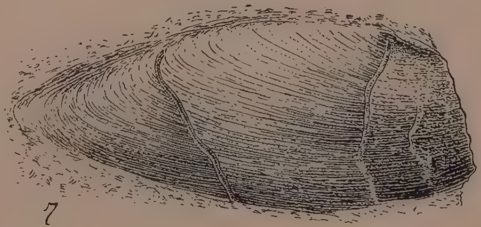

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